CHEMICAL OXIDATION STUDIES
GILT EDGE SULFIDE ORE

Report Prepared
For

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INTRODUCTION AND SUMMARY

In July, 1994, Dakota Mining Corporation commissioned a preliminary laboratory research program to evaluate chemical oxidation methods to enhance gold recoveries from the Gilt Edge sulfide ore. The study was aimed ultimately at determining the potential for treating Gilt Edge sulfide ore by chemical oxidation treatment, followed by conventional heap leaching. The test work was performed at Colorado Minerals Research Institute (CMRI), Golden, Colorado, at the direction of Douglas R. Shaw. The work was based on D. R. Shaw's April 11 and 27, 1994, proposals to Dakota.

The test work was performed on a 200 pound head sample provided by Brohm Mining Corporation from a 5,000 ton sample that was used for other work at the Gilt Edge mine site. Head assays of the laboratory sample are:

Au, oz/ton:	0.044 (0.046, duplicate)
Ag, oz/ton:	0.21 (0.18, duplicate)
$S_{(total)}$, %:	4.84
S^{2-}, %:	4.24
Fe, %:	5.53
As, ppm:	128
Cu, ppm:	543

The sample was stage crushed to approximately 90 weight % minus 3/8-inch for testing. The chemical oxidation tests, as well as the cyanidation step, being scoping in nature, were performed on slurries in bottle leaching tests.

Baseline (non-oxidative) leaching tests showed the cyanide soluble gold and silver contents to be 35.9 and 42.6%, respectively, based on 14 days of leaching and a sodium cyanide consumption of approximately 5 lb/ton of ore.

Four chemical oxidants were evaluated; namely, ferric sulfate, sodium chlorate, ferric chloride, and nitric acid. The test results showed that nitric acid, by far, was the most effective oxidant and resulted in gold and silver dissolutions in the cyanidation step of approximately 77.5% and 67%, respectively. Salient comparative test data were as follows.

Oxidant	Sulfide Oxidation, %	Oxidation Time, days	Gold Dissolutions in Cyanidation, %
None	--	--	35.9
Ferric sulfate	2.1	21	44.0
Sodium chlorate	8.5	21	60.6
Ferric chloride	0.7	21	53.2
Nitric acid	80.2	13[1/]	77.5
1/ Peak dissolutions occurred at 7 days			

The gold recovery of 77.5% in the nitric acid is based on a calculated head assay of 0.044 oz Au/ton. Assuming a constant residue assay, the recovery would be 80.0% for a head grade of 0.050 oz Au/ton.

The gold dissolution obtained with nitric acid oxidation was based on a nitric acid addition equivalent to 72% of the stoichiometric requirement for the sulfide sulfur content of the ore. Based on the metallurgical results, as well as the mineralogical examinations, even higher gold recoveries appear likely with higher nitric acid additions.

Sodium cyanide consumption in the cyanidation of the nitric acid oxidized ore was approximately 3.7 lb/ton. It is likely that the consumption can be reduced significantly with higher oxidation levels.

The nitric acid results were confirmed by assay/screen analyses which showed that gold dissolutions from the minus 1/4-inch fractions (i.e., 53.4 weight % of the crushed sample) were as high as 90.7%; whereas, the gold dissolutions averaged 70.7% from the plus 1/4-inch fractions (46.6 weight %). More evidence of oxidation was provided by surface area and solids pore volume measurements which showed a large increase in the porosity of the residue, in contrast to that of the feed, due to nitric acid treatment.

Mineralogical examination of the 3/8-inch crushed head sample showed the material to be relatively porous, due to extensive fracturing and the presence of micas and clays which would be expected to allow good diffusion of solutions. The mineralogy of the nitric acid residue provided vivid illustration of the diffusion mechanism of oxidation. The residue contains numerous examples where pyrite oxidation occurred along fracture paths, to the extent where abundant cavities exist that were formerly occupied by pyrite. Complete dissolution of pyrite also occurred in moderately impervious particles, which pyrite was only partially exposed at the periphery of gangue particles.

Recommendations are offered herein for follow up laboratory test work aimed at maximizing the oxidation rate by further systematic evaluation of nitric acid dosage. Due to the favorable porosity of the Gilt Edge ore, the material should respond positively to high rate oxidation in which it is possible that the oxidation time can be reduced to perhaps 1-2 hours. Such rapid oxidation opens important flowsheet possibilities for the heap leaching of Gilt Edge sulfide ore.

ORE SAMPLE CHARACTERIZATION

Description and Preparation

On July 11, 1994, 8 plastic pails of Gilt Edge sulfide ore were received at CMRI. The pails were identified as JT-1 through JT-8. The total sample net weight was 227 pounds. The samples were comprised of a mixture of finer grained material and rock fragments up to several inches in size. The materials were substantially dry upon receipt, but were air dried further in preparation for test work.

The samples were collected by front end loader from a 5,000 ton sample that was to be used for other work at the mine site. The material apparently was part of a 750,000 ton stockpile that was mined some two years ago and had been treated with an anti-bacterial agent.

In preparation for test work, the samples were combined and stage crushed to approximately 90 weight % minus 3/8-inch. The material was blended thoroughly and 2-kg charges were split out, and duplicate head pulps were prepared.

Upon examination of the crushed sample, it was observed that the material was a slight tan in color which suggested that it was slightly oxidized. Further examination under the binocular microscope revealed significant amounts of hematite, goethite, and evidence of other oxidation products, even though there were still considerable sulfides present. In discussion with Brohm, it was explained that some oxidation of the material was apparent due to weathering effects of the stockpiled sample at the site. The oxidation likely is due to the ubiquitous presence in the environment of sulfur and iron oxidizing bacteria. The metallurgical effects, although they may not be substantial in magnitude, of the differences in oxidation levels of the weathered material and freshly mined ore should be borne in mind when evaluating oxidation parameters.

A more detailed mineralogical description of the material is presented later in this report.

Head Assays

Table 1 shows chemical head assays of the test work sample.

The gold contents of 0.044 and 0.046 oz Au/ton were believed to be close to that expected for the Gilt Edge sulfide ore. The repeatability of the direct fire (1 AT basis) was reasonably good. The direct assays also agreed reasonably well with the average test calculated head assay of 0.043 oz Au/ton. Silver assays, approximately 0.20 oz Ag/ton, were more variable and reflected the degree of scatter often associated with fire assaying of materials of low silver contents.

Table 1
Gilt Edge Sulfide Ore Head Assays

Component	Assays
Au, oz/ton	0.44, 0.046
Ag, oz/ton	0.21, 0.18
Fe, %	5.53
Cu, ppm	543
As, ppm	128
S (total), %	4.84
S (SO_4), %	0.60 (1.80% SO_4)
S^{2-}, %	4.24
C(total), %	0.05
C (CO_2), %	0.02
pH, slurried sample of 90% minus 3/8-inch	2.2

Total sulfur content is 4.84% of which the sulfide sulfur content is 4.24%. Sulfate (SO_4) content is significant at 1.8%, and reflects the slightly oxidized nature of the sample.

Arsenic and copper contents, at approximately 0.013 and 0.054%, respectively, although relatively low, are significant metallurgically in that they are soluble in acidic oxidation treatments and, hence, report to the acid wash solution in the oxidative tests described herein. Arsenic also is a significant indicator of oxidation performance, as discussed herein.

Carbon content of the sample is minimal and it is understood that the Gilt Edge sulfide ore has little or no preg-robbing abilities. Inorganic carbon also is minimal, thus the material is not a significant acid consumer.

Assay/Size Analysis

A nominal minus 3/8-inch head sample was wet/dry screened and the fractions assayed for gold and total sulfur. Component distributions are shown in Table 2.

The distributions of gold and silver were not uniform by size in the crushed samples. Gold assays increased significantly with finer particle sizes, and sulfur analyses also increased in the finer sizes in approximate proportion to the increase in gold assays, except for the minus 100-mesh fraction. The plus 1/4-inch fraction, although the lowest in gold assays, contained 51.2 weight % and 26.5% of the gold. Due to the high gold tenor, the minus 100-mesh fraction contained as much as 39.4% of the gold, even though the fraction represented only 16.5 weight %.

An assay/size analysis also was performed on the residue from an oxidation test to determine gold dissolutions data by size. The results are described subsequently in this report.

Porosity/Surface Area

The results of porosity, surface area, and pore radius measurements of the crushed sample are shown below in Table 3.

Table 3
Surface Area and Pore Volume /Radius Data

Measurement	Results
Surface Area, BET	1.56 m^2/gram
Pore volume	0.0144 cc/gram
Average Pore Radius	1.85 Å (Angstrom units)

Table 2
Crushed Feed Assay/Size Analysis

Size Fraction	Weight, %	Weight, % Passing	Assays, Au, oz/ton	Assays, $S_{(T)}$, %	Distributions, % Au	Distributions, % $S_{(T)}$
Plus 1/4-inch	51.22	48.78	0.031	3.33	26.5	35.9
1/4-inch x 10-mesh	14.33	34.45	0.033	3.45	7.9	10.4
10 x 20-mesh	7.00	27.45	0.048	5.46	5.7	8.0
20 x 35-mesh	4.63	22.82	0.075	8.57	5.8	8.4
35 x 65-mesh	4.49	18.33	0.150	14.33	11.2	13.5
65 x 100-mesh	1.82	16.51	0.117	13.55	3.5	5.2
Minus 100-mesh	16.51	--	0.143	5.34	39.4	18.6
Head (Calculated)	100.00	--	0.060	4.75	100.0	100.0
Assay, (average direct)	--	--	0.045	4.84	--	--

The above determinations were performed by Quantachrome Corporation. The analyses used nitrogen as the gas type. The pore volume is that for the solids volume only, and does not include void space around the solids.

The same measurements were performed on an oxidized residue and these are discussed further later in this report.

pH

A pH of 2.2 was measured initially upon slurrying of the nominal 3/8-inch sample in laboratory tap water (pH 7.2) to 50% solids. The pH did not change significantly after about 1 hour of mixing of the slurry. The results indicated that some oxidation or sulfation of the sample had occurred, this being consistent with other observations made in this work regarding the sample nature. Although the liquid phase of the slurry was not analyzed, it is possible that it would contain significant quantities of soluble components such as iron, sulfate, copper, etc. Ideally, from the pH definition, the liquor would contain 0.31 g of free H_2SO_4/l.

BASELINE LEACHING TESTS

Duplicate bottle cyanide leaching tests were conducted on the crushed sample to determine gold solubilities and reagent consumptions, as a basis for comparison with the subsequent oxidation/cyanide leaching tests.

Baseline leaching conditions were as follows:

Feed Charge:	1,000 grams of 90% minus 3/8-inch crushed sample
% Solids:	50 (tap water)
NaCN:	1.0 g/l, maintained (equivalent to initial NaCN addition of 2.0 lb/ton ore)
CaO:	to maintain pH $\pm$ 11.0
Vessel:	Bottle roll
Leaching time:	14 days

The prolonged leaching time was used to ensure a reliable determination of the maximum cyanide soluble gold content of the crushed sample.

Leaching results are summarized below.

Table 4
Baseline Leaching Results

Test No.	Calculated Head Assays, oz/ton		Leach Residue, Assays, oz/ton		14 Day Dissolutions, %	
	Au	Ag	Au	Ag	Au	Ag
1	0.041	0.105	0.026	0.060	35.9	42.6
2	0.031	0.088	0.016	0.040	48.8	54.4

The tests did not compare well due to sizable calculated head and residue assay disparities. The test No. 2 residue assay, although repeatable, likely was errant and therefore was responsible for the low calculated head assay. The leach liquors for the tests were almost identical as follows.

Test No.	Liquor Assays, mg/l	
	Au	Ag
1	0.42	1.29
2	0.41	1.27

Test No. 1 was selected as being the most reliable baseline test, with a gold dissolution of 35.9%. The result, to some degree, likely reflected the partial oxidation of the ore sample provided for test work.

Sodium cyanide consumptions were 5.42 and 4.48 lb/ton of ore, respectively for tests No. 1 and 2; whereas, total lime additions were 14.3 and 14.5 lb/ton of ore for the same respective tests. These high consumptions reflected the high sulfide content of the material, as well as its acidic nature.

OXIDATION/CYANIDE LEACHING TESTS

Oxidation tests were performed on the 90% minus 3/8-inch crushed sample to evaluate four chemical oxidants; namely, ferric sulfate, sodium chlorate, ferric chloride, and nitric acid. The tests were conducted in bottles according to the following schedule.

Table 5
Bottle Leaching Schedule

Test No.	Reagent				Oxidation Time, days
	Type	Addition, lb/ton ore		Aqueous Concentration, gpl 2/	
		Initial	Total		
3	Ferric Sulfate $Fe_2(SO_4)_3 \cdot x\,H_2O$	59.4	118.8 1/	30/60 1/	21
4	Sodium Chlorate $NaClO_3$	39.2	39.2 1/	20	21
5	Ferric Chloride $FeCl_3 \cdot 6\,H_2O$	39.6	79.2 1/	20/40 1/	21
6	Nitric Acid (HNO_3)	206.1	296.8 1/	--	13

1/ Reagent concentration increased to the levels shown on fourteenth day, except for HNO_3 which was increased on the sixth day.
2/ Concentration does not include water of hydration.

Procedures

The tests were begun by mixing into the 2-kg crushed samples approximately one-half of the desired reagent addition in a concentrated solution adjusted as necessary to arrive at approximately 10-11% moisture in the ore. The reagents were mixed thoroughly by hand blending on a rolling cloth that was placed in a vented hood. The samples were placed in plastic buckets and allowed to cure for three days. Each bucket was vented to appropriate scrubbers to contain off-gases. The only noticeable off gas was from the nitric acid test in which significant NO_x was generated immediately upon acid contact with the ore. The amount of NO_x that evolved diminished gradually over a few hours after initial contact. The NO_x level was approximately 500-600 ppm after one hour of curing and decreased to about 15-25 ppm in the head space of the bucket after 3 days.

The cured samples were transferred to leaching bottles and water and additional reagent was added to obtain a slurry density of 50% solids. The bottles then were mixed continuously for twenty one days, except for the nitric acid test which was terminated after 13 days. Hydrochloric acid was added to the sodium chlorate and ferric chloride tests and sulfuric acid was added to the ferric sulfate test, all to maintain a slurry pH of 1 or less. No additional acid was necessary for the nitric acid test.

After 6 days of oxidation, more nitric acid was added to bring the total addition to 296.8 lb 100% HNO_3/ton of ore, or approximately 72% of the stoichiometric quantity for the sulfide sulfur content (4.24%) of the ore. The stoichiometry was based on the published equation shown below and assumes that all of the S^{2-} is present as pyrite.

$$2\ FeS_2 + 10HNO_3 \rightarrow Fe_2(SO_4)_3 + H_2SO_4 + 10NO\uparrow + 4H_2O \quad (1)$$

Additional ferric sulfate and ferric chloride were added to the respective tests on the fourteenth day of oxidation.

Liquor samples were taken regularly for iron and arsenic assays as key indicators of the degree of oxidation and dissolution. Copper also was followed because of its know relative ease of solubility in oxidizing weak acids, but is of less importance in respect of the project objective since the copper sulfide mineral, i.e., chalcopyrite, is unlikely to be associated with much of the gold, in contrast to that of pyrite and, possibly, arsenopyrite.

Aqueous phase emf data showed moderate degrees of oxidation (i.e., -400 to -600 m.v.) for ferric sulfate and the chloride reagents, but the emf's were as high as about -700 m.v. in the nitric acid test.

At the completion of the oxidation periods, the slurries were filtered and the residues were water washed. The wash solutions were assayed for iron, arsenic, and copper for the metallurgical balances. The washed residues were repluped with tap water to 50% solids slurries and cyanide leached for 48 hours, except for the nitric acid tests in which one-half of the slurry was leached for an additional 48 hours. Lime was added to the slurries initially to maintain a pH of approximately 11, and sodium cyanide addition was maintained at 1 g/l of solution, the same as used for the baseline tests. No active carbon was added due to the fear of carbon attritioning from the mixing of coarse ore particles, and assuming that the ore had no significant preg-robbing ability, even after oxidation. After cyanidation, the slurries were filtered and the residues were water washed and dried and prepared for assays for gold, silver, iron, arsenic, and copper.

Results

A summary of oxidation and cyanide results is shown in Table 6, and dissolution profiles for iron, arsenic, and copper are shown in Figures 1 through 3. Tables 7 through 10 show oxidation test operating data and analytical results, as presented by CMRI.

(Text continues on page 28)

Table 6
Summary Results of Chemical Oxidation and Cyanidation
(Minus 3/8-inch) - Gilt Edge Sulfide Ore

Test No.	Oxidation Reagent	OXIDATION				
		Time, Days	DISSOLUTIONS, %			Approximate S^{2-} Conversion, %
			$Fe_{(total)}$	As	Cu	
1	None-Baseline	--	--	--	--	--
3	Ferric Sulfate	21	19.9	31.0	88.8	2.1
4	Sodium Chlorate	21	10.7	15.0	79.4	8.5
5	Ferric Chloride	21	5.8	4.8	84.9	0.7
6	Nitric Acid	13	64.3	73.0	91.0	80.2

Test No.	Oxidation Reagent	CYANIDATION			Leach Residue Assays, oz Au/ton	Test Calculated Head Assays, oz Au/ton
		Au Dissolution, %	Reagent Consumptions lb/ton ore			
			NaCN	CaO[1/]		
1	None-Baseline	35.9	4.95	14.4	0.026	0.041
3	Ferric Sulfate	44.0	3.58	39.8	0.030	0.054
4	Sodium Chlorate	60.6	2.38	18.6	0.014	0.036
5	Ferric Chloride	53.2	2.14	19.2	0.019	0.041
6	Nitric Acid	77.5	3.68	24.3	0.010	0.044

1/ Lime addition

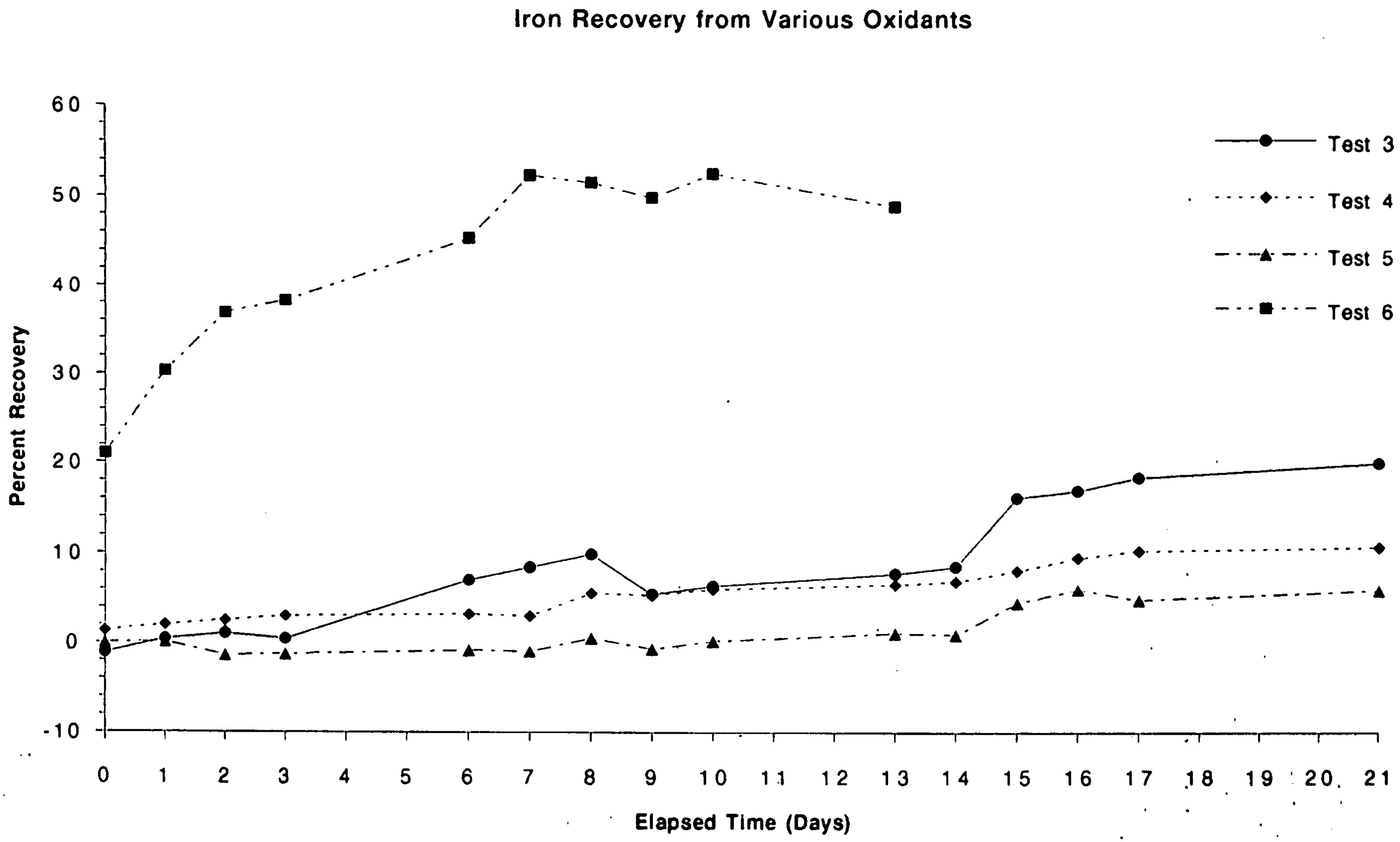
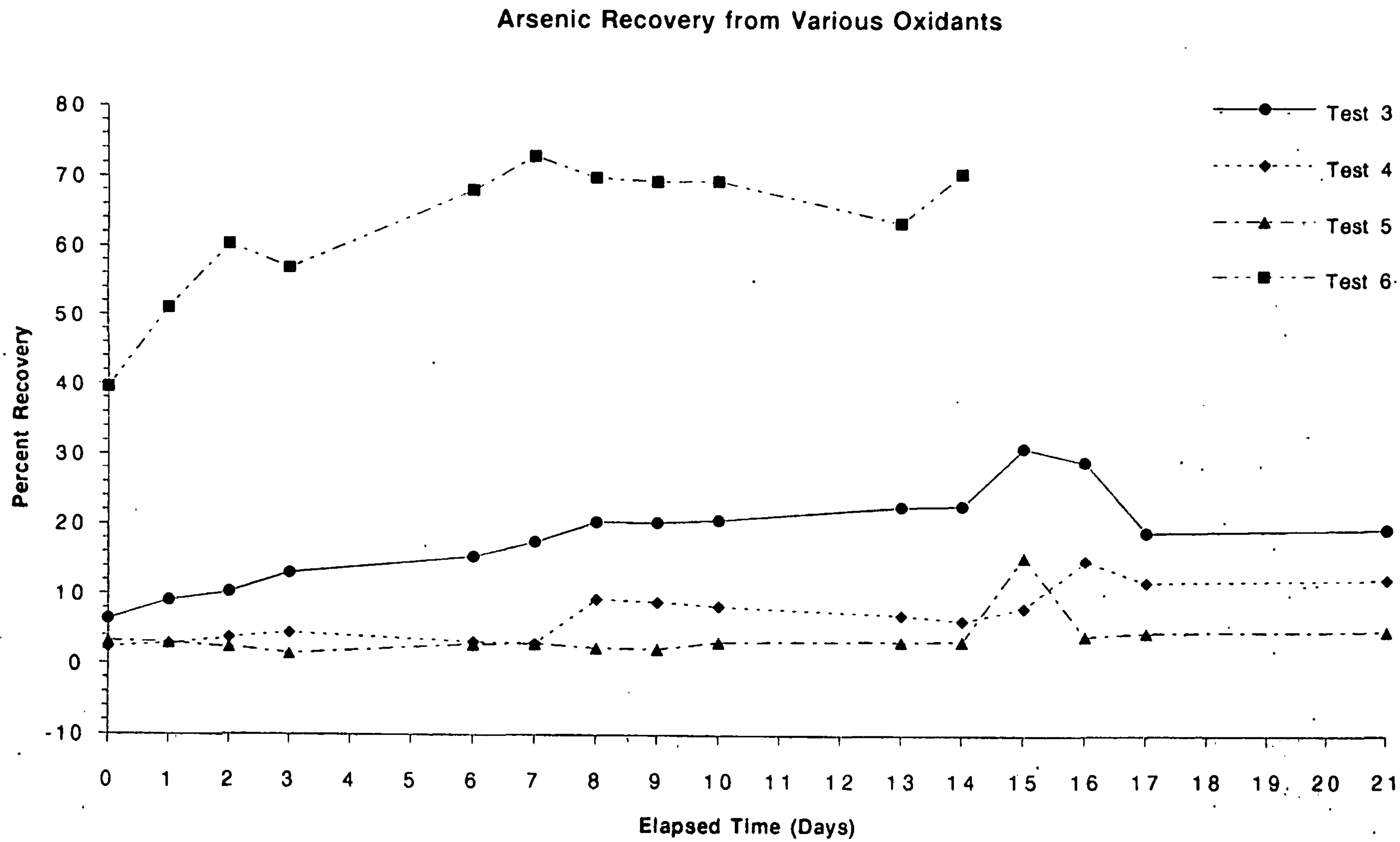

Iron Recovery from Various Oxidants
Percent Recovery
Elapsed Time (Days)
Test 3
Test 4
Test 5
Test 6
60
50
40
30
20
10
0
-10
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

FIGURE 1



Arsenic Recovery from Various Oxidants
Percent Recovery
80
70
60
50
40
30
20
10
0
-10
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Elapsed Time (Days)
Test 3
Test 4
Test 5
Test 6

FIGURE 2

Copper Recovery from Various Oxidants

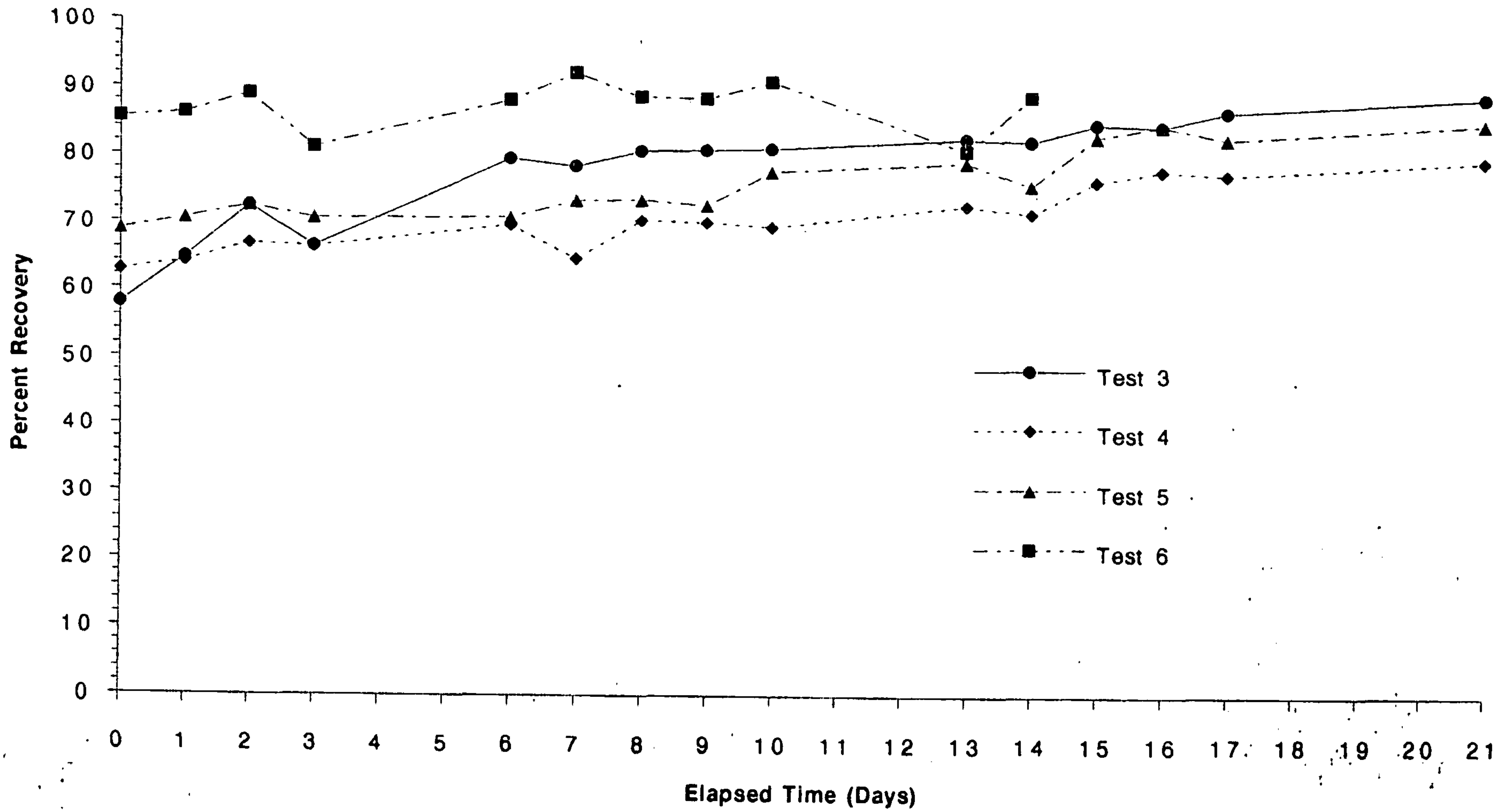


FIGURE 3

Table 7
Oxidation Test Report - Ferric Sulfate

Sample Weight (lbs) 4.409 | Reagent Fe Added (mg): 16,744.19

Au (oz/T):	0.044	Ag (oz/T):	0.21	Fe (%):	5.53	Cu (ppm)	543.0	As (ppm):	128.0
mg Au:	3.02	mg Ag:	14.40	mg Fe:	110,594.98	mg Cu:	1,085.95	mg As:	255.99
				Total Fe (mg):	127,339.17				

Target pH: <1.0 | NaCN (lbs/T): N/A

Lime Wt (grams): N/A | NaCN Wt (grams): N/A

Date	Day	Volume (liters)	Sample Volume (mls)	pH	Eh (mv)	Free NaCN (lbs/T)	Dissolved O2 (ppm)	Fe Assay (ppm)	mg Fe	Sample Fe (mg)	Cumulative mg Fe	Daily Fe Recovery (%)	Cumulative Fe Recovery (%)
16-Aug-94	0	1.98	81	1.52	520	N/A	N/A	7838.0	15519.2	634.9	634.9	-1.11	-1.11
17-Aug-94	1	1.98	88	1.16	458	N/A	N/A	8361.0	16554.8	735.8	1370.6	0.94	0.40
18-Aug-94	2	1.98	102	1.07	431	N/A	N/A	8322.0	16477.6	848.8	2219.5	-0.07	1.00
19-Aug-94	3	1.98	113	1.13	425	N/A	N/A	7560.0	14968.8	854.3	3073.8	-1.36	0.40
22-Aug-94	6	1.98	111	0.77	427	N/A	N/A	10860.0	21502.8	1205.5	4279.2	5.91	7.08
23-Aug-94	7	1.98	100	0.77	434	N/A	N/A	11040.0	21859.2	1104.0	5383.2	0.32	8.49
24-Aug-94	8	1.98	103	1.00	419	N/A	N/A	11280.0	22334.4	1161.8	6545.1	0.43	9.92
25-Aug-94	9	1.98	101	0.81	427	N/A	N/A	8205.0	16245.9	828.7	7373.8	-5.51	5.47
26-Aug-94	10	1.98	97	1.10	421	N/A	N/A	8308.0	16449.8	805.9	8179.7	0.18	6.40
29-Aug-94	13	1.98	97	0.98	414	N/A	N/A	8671.0	17168.6	841.1	9020.7	0.65	7.78
30-Aug-94	14	1.98	104	0.85	404	N/A	N/A	8659.0	17144.8	900.5	9921.3	-0.02	8.52
31-Aug-94	15	1.98	95	1.20	426	N/A	N/A	20890.0	41362.2	1984.6	11905.8	6.76	16.09
01-Sep-94	16	1.98	97	0.94	421	N/A	N/A	20310.0	40213.8	1970.1	13875.9	-1.04	16.85
02-Sep-94	17	1.98	86	0.87	430	N/A	N/A	20160.0	39916.8	1733.8	15609.7	-0.27	18.36
06-Sep-94	21	1.98	1980	0.91	421			20160.0	39916.8	39916.8	55526.5	0.00	19.93

Totals: 3355

Total (mg)	55526.5
Solution Recovery (%)	43.61
Residue Assay (%)	5.25
"Hd/Tl" Recovery (%)	5.06
Calc Hd (%)	7.19
Assay Hd (%)	5.53
Accountability (%)	130.00

Table 7 cont'd
Oxidation Test Report - Ferric Sulfate

Date	Cu Assay (ppm)	mg Cu	Sample Cu (mg)	Cumulative mg Cu	Daily Cu Recovery (%)	Cumulative Cu Recovery (%)	As Assay (ppm)	mg As	Sample As (mg)	Cumulative mg As	Daily As Recovery (%)	Cumulative As Recovery (%)
16-Aug-94	317.6	628.8	25.7	25.7	57.91	57.91	8.33	16.5	0.7	0.7	6.44	6.44
17-Aug-94	341.50	676.2	30.1	55.8	4.36	64.63	11.43	22.6	1.0	1.7	2.40	9.10
18-Aug-94	369.60	731.8	37.7	93.5	5.12	72.52	12.47	24.7	1.3	3.0	0.80	10.30
19-Aug-94	317.00	627.7	35.8	129.3	-9.59	66.41	15.40	30.5	1.7	4.7	2.27	13.06
22-Aug-94	371.20	735.0	41.2	170.5	9.88	79.59	17.51	34.7	1.9	6.6	1.63	15.38
23-Aug-94	344.10	681.3	34.4	204.9	-4.94	78.44	19.27	38.2	1.9	8.6	1.36	17.50
24-Aug-94	339.10	671.4	34.9	239.8	-0.91	80.70	21.95	43.5	2.3	10.8	2.07	20.32
25-Aug-94	322.70	638.9	32.6	272.4	-2.99	80.92	20.73	41.0	2.1	12.9	-0.94	20.26
26-Aug-94	307.40	608.7	29.8	302.2	-2.79	81.13	20.10	39.8	1.9	14.9	-0.49	20.59
29-Aug-94	300.90	595.8	29.2	331.4	-1.19	82.70	21.64	42.8	2.1	17.0	1.19	22.55
30-Aug-94	284.20	562.7	29.6	361.0	-3.04	82.34	20.85	41.3	2.2	19.1	-0.61	22.75
31-Aug-94	282.90	560.1	26.9	387.9	-0.24	84.82	30.39	60.2	2.9	22.0	7.38	30.98
01-Sep-94	267.70	530.0	26.0	413.8	-2.77	84.53	26.35	52.2	2.6	24.6	-3.12	28.98
02-Sep-94	266.20	527.1	22.9	436.7	-0.27	86.64	12.12	24.0	1.0	25.6	-11.01	18.98
06-Sep-94	266.20	527.1	527.1	963.8	0.00	88.75	12.12	24.0	24.0	49.6	0.00	19.38

	Cu
Total (mg)	963.8
Solution Recovery (%)	88.75
Residue Assay (ppm)	68.9
"Hd/Tl" Recovery (%)	87.31
Calc Hd (ppm)	550.82
Assay Hd (ppm)	543.00
Accountability (%)	101.44

	As
Total (mg)	49.6
Solution Recovery (%)	19.38
Residue Assay (ppm)	137.0
"Hd/Tl" Recovery (%)	-7.03
Calc Hd (ppm)	161.81
Assay Hd (ppm)	128.00
Accountability (%)	126.41

Table 8
Oxidation Test Report - Sodium Chlorate

Sample Weight (lbs)	4.409	Reagent Fe Added (mg):	0.00

Au (oz/T):	0.044	Ag (oz/T):	0.21	Fe (%):	5.53	Cu (ppm)	543.0	As (ppm):	128.0
mg Au:	3.02	mg Ag:	14.40	mg Fe:	110,594.98	mg Cu:	1,085.95	mg As:	255.99
				Total Fe (mg):	110,594.98				

Target pH:	~1.0	NaCN (lbs/T):	N/A
Lime Wt (grams):	N/A	NaCN Wt (grams):	N/A

Date	Day	Volume (liters)	Sample Volume (mls)	pH	Eh (mv)	Free NaCN (lbs/T)	Dissolved O2 (ppm)	Fe Assay (ppm)	mg Fe	Sample Fe (mg)	Cumulative mg Fe	Daily Fe Recovery (%)	Cumulative Fe Recovery (%)
16-Aug-94	0	1.96	94	1.78	604	N/A	N/A	766.0	1500.6	72.0	72.0	1.36	1.36
17-Aug-94	1	1.96	101	1.26	578	N/A	N/A	1091.0	2137.3	110.2	182.2	0.58	2.00
18-Aug-94	2	1.96	100	1.42	546	N/A	N/A	1309.0	2564.3	130.9	313.1	0.39	2.48
19-Aug-94	3	1.96	105	1.47	560	N/A	N/A	1521.0	2979.6	159.7	472.8	0.38	2.98
22-Aug-94	6	1.96	103	1.52	537	N/A	N/A	1562.0	3060.0	160.9	633.7	0.07	3.19
23-Aug-94	7	1.96	86	1.40	528	N/A	N/A	1370.0	2683.8	117.8	751.5	-0.34	3.00
24-Aug-94	8	1.96	100	0.80	522	N/A	N/A	2753.0	5393.1	275.3	1026.8	2.45	5.56
25-Aug-94	9	1.96	92	0.74	490	N/A	N/A	2503.0	4903.4	230.3	1257.1	-0.44	5.36
26-Aug-94	10	1.96	98	0.84	479	N/A	N/A	2755.0	5397.0	275.5	1532.6	0.45	6.02
29-Aug-94	13	1.96	99	0.9	448	N/A	N/A	2940.0	5759.5	270.5	1803.1	0.33	6.59
30-Aug-94	14	1.96	101	0.9	451	N/A	N/A	2976.0	5830.0	291.6	2094.7	0.06	6.90
31-Aug-94	15	1.96	108	1.20	439	N/A	N/A	3514.0	6883.9	379.5	2474.2	0.95	8.12
01-Sep-94	16	1.96	113	0.92	456	N/A	N/A	4126.0	8082.8	466.2	2940.5	1.08	9.55
02-Sep-94	17	1.96	94	1.10	460	N/A	N/A	4321.0	8464.8	406.2	3346.6	0.35	10.31
06-Sep-94	21	1.96	2130	1.08	451			4321.0	8464.8	9203.7	12550.4	0.00	10.68
		Totals:	3524										

Total (mg)	12550.4
Solution Recovery (%)	11.35
Residue Assay (%)	5.22
"Hd/Tl" Recovery (%)	5.61
Calc Hd (%)	5.85
Assay Hd (%)	5.53
Accountability (%)	105.74

Table 8 cont'd

Oxidation Test Report - Sodium Chlorate

Date	Cu Assay (ppm)	mg Cu	Sample Cu (mg)	Cumulative mg Cu	Daily Cu Recovery (%)	Cumulative Cu Recovery (%)	As Assay (ppm)	mg As	Sample As (mg)	Cumulative mg As	Daily As Recovery (%)	Cumulative As Recovery (%)
16-Aug-94	347.6	680.9	32.7	32.7	62.71	62.71	3.01	5.9	0.3	0.3	2.30	2.30
17-Aug-94	338.10	662.3	34.1	66.8	-1.71	64.00	3.69	7.2	0.4	0.7	0.52	2.93
18-Aug-94	335.90	658.0	33.6	100.4	-0.40	66.75	4.56	8.9	0.5	1.1	0.67	3.75
19-Aug-94	316.50	620.0	33.2	133.6	-3.50	66.34	5.22	10.2	0.5	1.7	0.51	4.43
22-Aug-94	317.90	622.8	32.7	166.4	0.25	69.65	3.30	6.5	0.3	2.0	-1.47	3.17
23-Aug-94	273.20	535.2	23.5	189.9	-8.06	64.61	2.83	5.5	0.2	2.2	-0.36	2.94
24-Aug-94	293.40	574.8	29.3	219.2	3.64	70.41	11.03	21.6	1.1	3.3	6.28	9.32
25-Aug-94	276.60	541.9	25.4	244.7	-3.03	70.08	9.90	19.4	0.9	4.3	-0.86	8.88
26-Aug-94	260.20	509.7	25.5	270.2	-2.96	69.47	8.73	17.1	0.9	5.1	-0.90	8.34
29-Aug-94	265.30	519.7	26.3	296.4	0.92	72.74	6.68	13.1	0.7	5.8	-1.57	7.11
30-Aug-94	245.20	480.3	24.8	321.2	-3.63	71.53	5.32	10.4	0.5	6.3	-1.04	6.33
31-Aug-94	259.90	509.1	28.1	349.3	2.65	76.46	7.49	14.7	0.8	7.1	1.66	8.20
01-Sep-94	254.20	498.0	28.7	378.0	-1.03	78.02	15.93	31.2	1.8	8.9	6.46	14.97
02-Sep-94	235.70	461.7	22.2	400.2	-3.34	77.33	10.89	21.3	1.0	9.9	-3.86	11.82
06-Sep-94	235.70	461.7	502.0	902.2	0.00	79.37	10.89	21.3	23.2	33.1	0.00	12.22

	Cu		As
Total (mg)	902.2	Total (mg)	33.1
Solution Recovery (%)	83.08	Solution Recovery (%)	12.95
Residue Assay (ppm)	69.8	Residue Assay (ppm)	172.0
"Hd/Tl" Recovery (%)	87.15	"Hd/Tl" Recovery (%)	-34.38
Calc Hd (ppm)	520.92	Calc Hd (ppm)	188.57
Assay Hd (ppm)	543.00	Assay Hd (ppm)	128.00
Accountability (%)	95.93	Accountability (%)	147.32

Table 9
Oxidation Test Report - Ferric Chloride

Sample Weight (lbs)	4.409	Reagent Fe Added (mg):	13,752.31

Au (oz/T):	0.044	Ag (oz/T):	0.21	Fe (%):	5.53	Cu (ppm)	543.0	As (ppm):	128.0
mg Au:	3.02	mg Ag:	14.40	mg Fe:	110,594.98	mg Cu:	1,085.95	mg As:	255.99
				Total Fe (mg):	124,347.29				

Target pH:	~1.0	NaCN (lbs/T):	N/A
Lime Wt (grams):	N/A	NaCN Wt (grams):	N/A

Date	Day	Volume (liters)	Sample Volume (mls)	pH	Eh (mv)	Free NaCN (lbs/T)	Dissolved O2 (ppm)	Fe Assay (ppm)	mg Fe	Sample Fe (mg)	Cumulative mg Fe	Daily Fe Recovery (%)	Cumulative Fe Recovery (%)
16-Aug-94	0	1.98	100	1.25	572	N/A	N/A	6971.0	13802.6	697.1	697.1	0.05	0.05
17-Aug-94	1	1.98	102	0.89	530	N/A	N/A	6631.0	13129.4	676.4	1373.5	-0.61	0.07
18-Aug-94	2	1.98	93	1.07	498	N/A	N/A	5475.0	10840.5	509.2	1882.6	-2.07	-1.39
19-Aug-94	3	1.98	116	1.18	487	N/A	N/A	5268.0	10430.6	611.1	2493.7	-0.37	-1.30
22-Aug-94	6	1.98	93	1.24	464	N/A	N/A	5229.0	10353.4	486.3	2980.0	-0.07	-0.82
23-Aug-94	7	1.98	117	1.20	458	N/A	N/A	4903.0	9707.9	573.7	3553.7	-0.58	-0.96
24-Aug-94	8	1.98	100	0.75	447	N/A	N/A	5457.0	10804.9	545.7	4099.4	0.99	0.55
25-Aug-94	9	1.98	98	0.91	454	N/A	N/A	4481.0	8872.4	439.1	4538.5	-1.75	-0.71
26-Aug-94	10	1.98	97	0.80	447	N/A	N/A	4767.0	9438.7	462.4	5000.9	0.51	0.20
29-Aug-94	13	1.98	98	0.87	431	N/A	N/A	5004.0	9907.9	490.4	5491.3	0.42	1.05
30-Aug-94	14	1.98	102	1	420	N/A	N/A	4687.0	9280.3	478.1	5969.4	-0.57	0.92
31-Aug-94	15	1.98	96	1.15	463	N/A	N/A	13370.0	26472.6	1283.5	7252.9	3.11	4.46
01-Sep-94	16	1.98	105	0.87	464	N/A	N/A	13580.0	26888.4	1425.9	8678.8	0.38	6.00
02-Sep-94	17	1.98	96	0.89	466	N/A	N/A	12180.0	24116.4	1169.3	9848.1	-2.51	4.78
06-Sep-94	21	1.98	2205	1.03	457	N/A	N/A	12180.0	24116.4	26856.9	36705.0	0.00	5.84
		Totals:	3618										

Total (mg)	36705.0
Solution Recovery (%)	29.52
Residue Assay (%)	5.92
"Hd/Tl" Recovery (%)	-7.05
Calc Hd (%)	7.07
Assay Hd (%)	5.53
Accountability (%)	127.81

Table 9 cont'd

Oxidation Test Report - Ferric Chloride

Date	Cu Assay (ppm)	mg Cu	Sample Cu (mg)	Cumulative mg Cu	Daily Cu Recovery (%)	Cumulative Cu Recovery (%)	As Assay (ppm)	mg As	Sample As (mg)	Cumulative mg As	Daily As Recovery (%)	Cumulative As Recovery (%)
16-Aug-94	377.6	747.6	37.8	37.8	68.85	68.85	4.22	8.4	0.4	0.4	3.26	3.26
17-Aug-94	367.90	728.4	37.5	75.3	-1.77	70.56	3.69	7.3	0.4	0.8	-0.41	3.02
18-Aug-94	359.60	712.0	33.4	108.7	-1.51	72.50	2.66	5.3	0.2	1.0	-0.80	2.37
19-Aug-94	332.50	658.4	38.6	147.3	-4.94	70.64	1.44	2.9	0.2	1.2	-0.94	1.52
22-Aug-94	314.00	621.7	29.2	176.5	-3.37	70.82	3.00	5.9	0.3	1.5	1.21	2.79
23-Aug-94	313.40	620.5	36.7	213.2	-0.11	73.39	3.00	5.9	0.4	1.8	0.00	2.90
24-Aug-94	295.00	584.1	29.5	242.7	-3.35	73.42	2.05	4.1	0.2	2.0	-0.73	2.31
25-Aug-94	275.80	546.1	27.0	269.7	-3.50	72.63	1.78	3.5	0.2	2.2	-0.21	2.18
26-Aug-94	290.50	575.2	28.2	297.9	2.68	77.80	3.00	5.9	0.3	2.5	0.94	3.19
29-Aug-94	283.60	561.5	27.8	325.7	-1.26	79.14	3.00	5.9	0.3	2.8	0.00	3.30
30-Aug-94	251.10	497.2	25.6	351.3	-5.93	75.77	3.00	5.9	0.3	3.1	0.00	3.42
31-Aug-94	277.90	550.2	26.7	378.0	4.89	83.02	18.50	36.6	1.8	4.9	11.99	15.53
01-Sep-94	273.60	541.7	28.7	406.7	-0.78	84.69	2.90	5.7	0.3	5.2	-12.07	4.15
02-Sep-94	248.30	491.6	23.8	430.5	-4.61	82.72	3.44	6.8	0.3	5.5	0.42	4.69
06-Sep-94	248.30	491.6	547.5	978.0	0.00	84.92	3.44	6.8	7.6	13.1	0.00	4.82

Total (mg)	978.0	Total (mg)	13.1
Solution Recovery (%)	90.06	Solution Recovery (%)	5.12
Residue Assay (ppm)	97.1	Residue Assay (ppm)	112.0
"Hd/Tl" Recovery (%)	82.12	"Hd/Tl" Recovery (%)	12.50
Calc Hd (ppm)	586.13	Calc Hd (ppm)	118.55
Assay Hd (ppm)	543.00	Assay Hd (ppm)	128.00
Accountability (%)	107.94	Accountability (%)	92.62

Table 10

Oxidation Test Report - Nitric Acid

Sample Weight (lbs)	4.409	Reagent Fe Added (mg):	0.00

Au (oz/T):	0.044	Ag (oz/T):	0.21	Fe (%):	5.53	Cu (ppm)	543.0	As (ppm):	128.0
mg Au:	3.02	mg Ag:	14.40	mg Fe:	110,594.98	mg Cu:	1,085.95	mg As:	255.99
				Total Fe (mg):	110,594.98				

Target pH:	~1.0	NaCN (lbs/T):	N/A
Lime Wt (grams):	N/A	NaCN Wt (grams):	N/A

Date	Day	Volume (liters)	Sample Volume (mls)	pH	Eh (mv)	Free NaCN (lbs/T)	Dissolved O2 (ppm)	Fe Assay (ppm)	mg Fe	Sample Fe (mg)	Cumulative mg Fe	Daily Fe Recovery (%)	Cumulative Fe Recovery (%)
16-Aug-94	0	2.01	107	0.54	797	N/A	N/A	11550.0	23215.5	1235.9	1235.9	20.99	20.99
17-Aug-94	1	2.01	114	0.45	720	N/A	N/A	16070.0	32300.7	1832.0	3067.8	8.21	30.32
18-Aug-94	2	2.01	112	0.67	700	N/A	N/A	18760.0	37707.6	2101.1	5169.0	4.89	36.87
19-Aug-94	3	2.01	97	0.77	703	N/A	N/A	18500.0	37185.0	1794.5	6963.5	-0.47	38.30
22-Aug-94	6	2.01	976	0.76	715	N/A	N/A	21489.0	43192.9	20973.3	27936.7	5.43	45.35
23-Aug-94	7	2.01	102	0.61	720	N/A	N/A	14900.0	29949.0	1519.8	29456.5	-11.98	52.34
24-Aug-94	8	2.01	108	0.60	714	N/A	N/A	13720.0	27577.2	1481.8	30938.3	-2.14	51.57
25-Aug-94	9	2.01	103	0.65	715	N/A	N/A	12060.0	24240.6	1242.2	32180.5	-3.02	49.89
26-Aug-94	10	2.01	93	0.60	711	N/A	N/A	12910.0	25949.1	1200.6	33381.1	1.54	52.56
29-Aug-94	13	2.01	2735	0.77	681	N/A	N/A	10300.0	20703.0	28170.5	61551.6	-4.74	48.90

Totals: 4547

Total (mg)	61551.6
Solution Recovery (%)	55.65
Residue Assay (%)	1.71
"Hd/Tl" Recovery (%)	69.08
Calc Hd (%)	4.79
Assay Hd (%)	5.53
Accountability (%)	86.58

Table 10 cont'd
Oxidation Test Report - Nitric Acid

Date	Cu Assay (ppm)	mg Cu	Sample Cu (mg)	Cumulative mg Cu	Daily Cu Recovery (%)	Cumulative Cu Recovery (%)	As Assay (ppm)	mg As	Sample As (mg)	Cumulative mg As	Daily As Recovery (%)	Cumulative As Recovery (%)
16-Aug-94	461.5	927.6	49.4	49.4	85.42	85.42	50.43	101.4	5.4	5.4	39.60	39.60
17-Aug-94	441.00	886.4	50.3	99.7	-3.79	86.17	62.36	125.3	7.1	12.5	9.37	51.07
18-Aug-94	431.70	867.7	48.4	148.0	-1.72	89.08	70.61	141.9	7.9	20.4	6.48	60.33
19-Aug-94	365.00	733.7	35.4	183.4	-12.35	81.19	62.29	125.2	6.0	26.5	-6.53	56.88
22-Aug-94	385.40	774.7	376.2	559.6	3.78	88.22	73.55	147.8	71.8	98.2	8.84	68.09
23-Aug-94	219.90	442.0	22.4	582.0	-30.63	92.23	44.07	88.6	4.5	102.7	-23.15	72.98
24-Aug-94	189.90	381.7	20.5	602.5	-5.55	88.74	37.93	76.2	4.1	106.8	-4.82	69.92
25-Aug-94	178.30	358.4	18.4	620.9	-2.15	88.48	35.20	70.8	3.6	110.5	-2.14	69.37
26-Aug-94	182.80	367.4	17.0	637.9	0.83	91.01	33.49	67.3	3.1	113.6	-1.34	69.45
29-Aug-94	119.80	240.8	327.7	965.5	-11.66	80.91	24.51	49.3	67.0	180.6	-7.05	63.61

	Cu		As
Total (mg)	965.5	Total (mg)	180.6
Solution Recovery (%)	88.91	Solution Recovery (%)	70.55
Residue Assay (ppm)	53.3	Residue Assay (ppm)	59.0
"Hd/Tl" Recovery (%)	90.18	"Hd/Tl" Recovery (%)	53.91
Calc Hd (ppm)	536.08	Calc Hd (ppm)	149.31
Assay Hd (ppm)	543.00	Assay Hd (ppm)	128.00
Accountability (%)	98.73	Accountability (%)	116.65

Oxidation

On the basis of iron and arsenic dissolutions, nitric acid was by far the most effective oxidant. Approximately 64.3% (peak level) of the total iron and 73.0% of the arsenic were solubilized during oxidation. However, since not all of the iron in the sample is present as sulfide iron, the amount of sulfide iron that was solubilized was calculated to be approximately 78% based on the iron and sulfide head assays and assuming that all of the sulfide is present as pyrite. The sulfide iron dissolution corresponds reasonably well with the total sulfide dissolution of as much as 80.2% based on the sulfur and sulfate analyses of the test feed and residue.

The iron and sulfide sulfur conversions (dissolution) of approximately 80% (rounded off) are nearly 10 percentage points higher than would be possible theoretically with a HNO_3 addition of 72% of the stoichiometric quantity. The disparity between the addition and conversion percentage likely reflects the degree of "natural" oxidation which was calculated to be approximately 12% based on the head assays of total sulfur (4.84) and sulfide sulfur (4.24%). Overall, therefore, there appears to be reasonable agreements between the oxidation data and reagent addition.

The cumulative iron and, especially, arsenic dissolutions appeared to decrease measurably during the last several days of oxidation. The results indicated that some re-precipitation of iron and arsenic occurred as basic ferric arsenates. This is possible due to free acid depletion with time and the high ferric iron to arsenic ratios in solution, which ratios would favor precipitation. It would be useful to change liquors periodically during the test to avoid re-precipitation, although it is unlikely that such a phenomenon would adversely affect the subsequent gold cyanidation behavior.

The other chemical oxidants were much less effective and resulted in low iron and arsenic solubilities and sulfide sulfur conversions. Ferric sulfate, however, appeared to provide the next highest iron and arsenic solubilities of 19.9 and 31%, respectively, but the results did not correlate well with the very low calculated sulfide sulfur conversions as did the nitric acid test results. There was small increase in iron and arsenic dissolutions in the ferric sulfate and ferric chloride tests when the reagent concentrations were increased on day 14. However, the iron solubilities leveled off again after only one day, and arsenic solubilities decreased, likely due to similar re-precipitation as observed for the nitric acid test. It is conceivable that higher oxidation levels would result with significantly higher reagent additions.

Copper dissolutions were highest (88-90%) with nitric acid and ferric sulfate, and were lower with the two chloride reagents.

Cyanidation

The highest gold dissolution of 77.5% was obtained from the nitric acid oxidized residue, based on a residue assay of 0.010 oz Au/ton and a calculated head of 0.044 oz Au/ton. Assuming a constant residue assay, the recovery would be 77.8% based on the average direct head of 0.045 oz Au/ton, and 80.0%, for example, if the head assay were 0.050 oz Au/ton.

Gold dissolutions were substantially completed after 48 hours of leaching. Leaching for another 48 hours resulted in an additional gold recovery of only approximately 2 percentage points. Total silver dissolution was 67.1%. Based on the mineralogy information presented later in this report, it is likely that significantly higher gold recoveries would result if larger amounts of nitric acid were to be added to cause sulfide sulfur conversions of greater than 80%.

Gold dissolutions were lower in the other tests, due to the lower oxidation levels. Dissolutions were from 44.0% to 60.6%, which are significantly higher than the baseline test. However, the calculated head assay spread ranged from 0.036 to 0.054 oz Au/ton, which variations made it difficult to draw valid comparisons. Again, residue assay anomalies appeared to be responsible for the variations. Consequently, there appears to be no systematic relationship between gold dissolutions and the sulfide sulfur conversions for the ferric sulfate and chloride reagents tests.

Sodium cyanide consumptions were relatively high for all the oxidation tests, and for the nitric acid test, the consumption was 3.68 lb/ton of ore. The high consumptions may have reflected the effects of cyanicides such as sulfides which were still present in the residue due to incomplete sulfide sulfur conversion. From previous test work experience, cyanide consumptions were very low in cases where virtually complete conversion of sulfides and cyanicides was caused by using comparatively higher stoichiometric additions of nitric acid than in this work. Future testing should address attempts to reduce cyanide consumptions on the Gilt Edge ore.

Lime addition in the nitric acid test was 24.3 lb/ton, which amount is a reflection of the degree of washing of the oxidized residue. Future work, therefore, should quantify more systematically the relationship between washing extent and reagent consumptions in cyanidation.

Residue Assay/Size Analysis

The cyanidation residue from the nitric acid test was subject to a assay/size analysis as shown in Table 11. When compared with the feed assay/size analysis (Table 2, page 10, of this report), the residue was finer grained, with, for example, 53.4 weight % passing 1/4-inch in the residue, versus 48.8 weight % passing the same size of the feed. The amount of minus 100-mesh material increased to 26.6 weight % in the residue from 16.6 weight % in the feed. The finer particle size distribution of the residue likely

Table 11
Nitric Acid Test Residue Assay/Size Analysis And Gold Recoveries By Size

Size Fraction	Weight, %	Cumalutive Weight, % Passing	Assays, Au, oz/ton	Assays, $S_{(T)}$ %	Distributions, % Au	Distributions, % $S_{(T)}$
Plus 1/4-inch	46.57	53.43	0.010	0.95	46.4	52.0
1/4-inch x 10-mesh	14.55	38.88	0.006	0.42	8.7	7.2
10 x 20-mesh	6.38	32.50	0.005	0.88	3.2	6.6
20 x 35-mesh	3.12	29.38	0.009	1.07	2.8	3.9
35 x 65-mesh	2.01	27.37	0.006	1.01	1.2	2.4
65 x 100-mesh	0.76	26.61	0.006	2.26	0.5	2.0
Minus 100-mesh	26.61	--	0.014	0.83	37.2	25.9
Head (Calculated)	100.00	--	0.010	0.85	100.0	100.0
Head (Assay)	--	--	0.010	1.24	--	--
			Gold Dissolutions by Size Fracition, %			
Size Fraction			Balance[1/]	Assay[2/]		
Plus 1/4-inch			70.7	67.7		
1/4-inch x 10-mesh			81.5	81.8		
10 x 20-mesh			90.6	89.6		
20 x 35-mesh			92.0	88.0		
35 x 65-mesh			98.2	96.0		
65 x 100-mesh			97.6	94.9		
Minus 100-mesh			84.2	90.2		

1/ Dissolutions calculated from metallurgical balance for each fraction.
2/ Dissolutions calculated from head and residue assays for each fraction.

reflected attritioning effects from the prolonged bottle leaching time which totalled 17 days for the oxidation and cyanidation stages. Particle decrepitation from the acid attack may also have contributed to the finer size distribution.

Approximately 46 and 37% (83% altogether) of the unleached gold occurred in the plus 1/4-inch and minus 100-mesh fractions. Similarly large distributions of unoxidized sulfur occurred in those same fractions.

Table 12 also shows the dissolutions of gold by particle size. The dissolutions were calculated based on head and residue assays, as well as by a metallurgical balance calculated for each fraction, to reflect the weight differences in the feed and residue. The dissolutions are substantially the same and show that gold dissolutions were lowest (i.e., 67.7-70.7%) in the plus 1/4-inch fraction, but averaged over 90% in the minus 1/4-inch material as shown by the follow summary results.

Table 12
Summary Results, Gold Recoveries by Size

Size Fraction	Weight %	Composite Gold Dissolutions, % By Size
Plus 1/4-inch	46.6	70.7
Minus 1/4-inch	53.4	90.7
Weighted Average	100.0	81.4

The weighted average gold dissolution of 81.4% confirmed reasonably closely the overall gold recovery of 77.5% calculated from the nitric acid test metallurgical balance. The slightly higher dissolution likely reflected the higher than normal calculated head assay of the feed assay/size analysis.

Based on experience, it is likely that the gold dissolutions can be improved from the coarse size fraction by using higher nitric acid additions.

Surface Area/Porosity of Residue

Table 13 shows a comparison of surface area, pore volume, and pore radii for the crushed feed sample and nitric acid test residue. The surface area and pore volume increased considerably in the residue sample than in the feed. The pore volume differential of almost two in this case probably is the most meaningful indicator of the effects of oxidation. The surface area increase in the residue appears out of proportion to what experience on other materials would indicate. Attritioning effects likely also contributed to the large surface area increase.

Table 13
Comparsion of Surface Areas and Porosities of Feed and HNO_3 Residue Samples

Sample	Physical Measurement Data		
	Surface Area m^2/gram	Solids Pore Volume cc/gram	Pore Radius Å
Feed	1.56	0.0144	185
HNO_3 Residue	7.56	0.0269	71.2

The pore radius decreased in the residue from that of the feed, which result is the opposite of that observed from experience. Ordinarily, the pore radius increases generally in proportion to the pore volume increase. It is quite conceivable, however, that the decreased pore radius in the residue reflected the precipitation of basis ferric arsenates in the various pores and channelways, which precipitates could easily result in smaller pore radii.

The above results are based on a relatively small number of rock fragments that can be used for the analyses. Consequently, a larger number of analyses need to be performed to reduce the experimental variation inherent in the use of small sample amounts for such determinations. However, the available results indicated that significant increases occurred in surface areas and porosities, and the results are consistent with other experience with nitric acid oxidation of ores similar in many respects to those of the Gilt Edge ore.

Mineralogy

Hazen Research, Inc., conducted mineralogical examinations of the crushed head sample and the oxidized and cyanide leached residue from the nitric acid test. The purposes were to determine the textural features of the feed and residue as such features relate to oxidation mechanisms, and to evaluate the occurrences of unleached gold and sulfides. Hazen's report, authored by Roland Schmidt, Mineralogist, follows in its entirety.

Samples

The samples received on September 29, 1994, consisted of screen fractions of head ore and the residue sample designated:

1. Dakota 943002
+6-mesh
6 x 10
10 x 20
20 x 35
35 x 65
65 x 100
-100

2. CN Leach Residue Test #6

Sample Preparation

For the investigation the head ore screen fractions, except the -100-mesh, were reconstituted into a single sample and the leach residue was wet screen at 100-mesh after ultrasonic dispersion to remove slimes. Both samples were first examined with a binocular microscope for gross features and particles in the 10-mesh x 1/4-inch size range were handpicked for polished section preparation to be used for subsequent microscopic analysis. A brief description of the microscopic observation follows.

Head Ore 3/8-inch x 100-mesh

Binocular microscope examination of the head ore showed that the sample consists mostly of light colored coarse and fine grained siliceous minerals and minor biotite or phlogopite and muscovite. Some particles are stained by iron oxides. Pyrite is very abundant, estimated 10-20%, occurring mainly as euhedral crystals and crystal aggregates both liberated and disseminated through the siliceous gangue particles. Pyrite euhedra are as coarse as 3 mm. Under low power magnification the rock particles are not noticeably fractured. A few gangue particles show cube-shaped cavities partially filled with earthy iron oxides derived from oxidation of euhedral pyrite. Microscopic polished section analysis at about 200x magnification showed pyrite as the dominant opaque mineral with minor amounts of goethite, hematite, anatase, and traces of chalcopyrite and pyrrhotite hosted in the siliceous matrix consisting mostly of quartz and feldspar with moderate clay alteration and minor carbonate ? veining. As already noted in the binocular microscopic examination, the majority of the pyrite occurs as single euhedral crystals and crystal aggregates both liberated and intergrown with the siliceous components. Frequently the pyrite carries gangue inclusions. Pyrite particle size shows a wide range varying from <10 microns to about 3 mm with an estimated average range of 200-400 microns. The goethite occurs chiefly along fractures, sometimes accompanied by carbonate ?, as interstitial fillings in siliceous matrix, as local colloform masses and occasionally as coatings on pyrite. Although no actual pyrite replacement was observed in the polished section, it is expected that goethite derived from pyrite oxidation which is consistent with earlier observations under the binocular microscope. Clay alteration usually occurs associated with feldspar but also as fillings of interstitial spaces and pores within the rock fabric. With respect to permeability, the gangue particles vary from highly impervious to moderately and highly fractured, however even more impervious particles show a significant degree of porosity with pores evidently occupied by clay minerals. Furthermore many of the gangue particles consist of relatively fine grained aggregates of the constituent minerals with abundant interstitial clays which would be expected to allow diffusion of solutions.

Cyanide Leach Residue 3/8-inch x 100-mesh

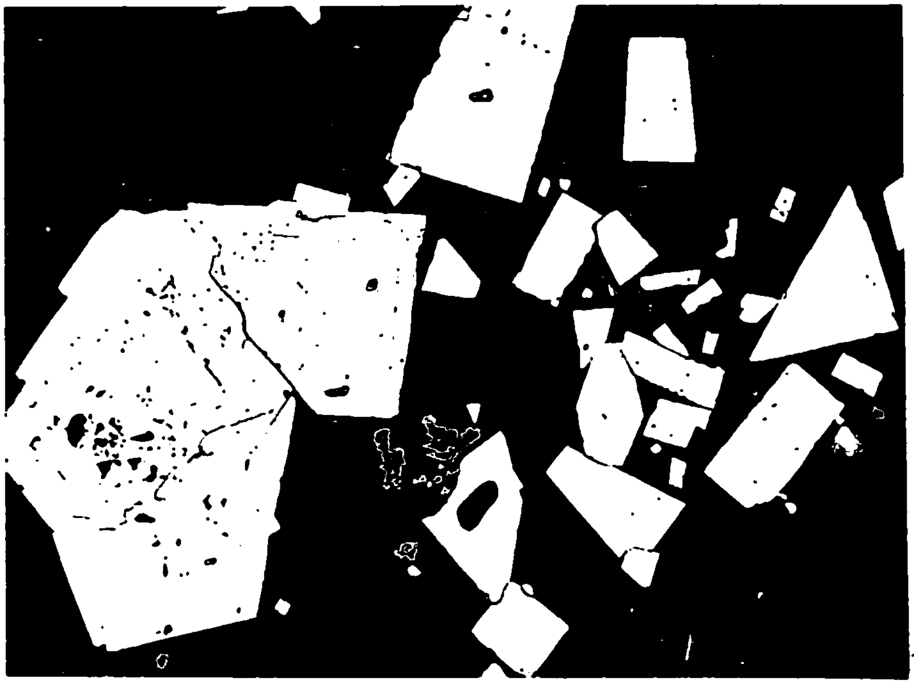
Binocular microscope examination showed noticeable rounding of the siliceous matrix particles and more widespread discoloration by iron oxides. An estimated 1-3% pyrite occurs as liberated corroded particles and <1% occurs as superficial partially exposed intergrowths with gangue matrix particles. Many of the matrix particles show square cavities formerly occupied by cubic pyrite crystals. Microscopic polished section study of 6-mesh x 1/4-inch particles in their cross-sections, showed a significant reduction of the pyrite content compared to the head sample, although pyrite is still plentiful amounting to an estimated 1-2%. In various gangue particles a complete range of pyrite dissolution can be observed varying from complete dissolution through partial dissolution to totally unaffected pyrite occurrences. Where complete dissolution has occurred the leached out cavities show the characteristic morphology of original euhedral pyrite. To establish whether there is a distinct correlation between the degree of fracturing and pyrite dissolution, the examination revealed numerous examples where pyrite dissolution from seemingly impervious gangue has occurred without any obvious connection to any fracturing. Difficult to explain are some occurrences showing evidence of complete dissolution of pyrite in moderately impervious particles in close proximity to residual pyrite partially exposed at the gangue particle periphery. Regarding these observations it must be kept in mind that in polished sections only two dimensions are observed which are not necessarily representative of the whole interior texture of a given particle.

Conclusions

From this investigation it is concluded that unrecovered gold occurs in residual pyrite which is still quite abundant in the nitric acid leach. Even though a certain portion of the residual pyrite occurs encapsulated in rather impervious gangue and would not be readily accessible to oxidation, there is abundant liberated pyrite and pyrite situated along fracture paths that could be readily oxidized with sufficient acid or longer retention times.

The CN soluble gold from the baseline tests, i.e., tests without prior oxidation, undoubtedly reflect the gold liberated from the pyrite during natural oxidation of some of the pyrite.

Figures 4 through 8 are photomicrographs illustrating some of the features described above.

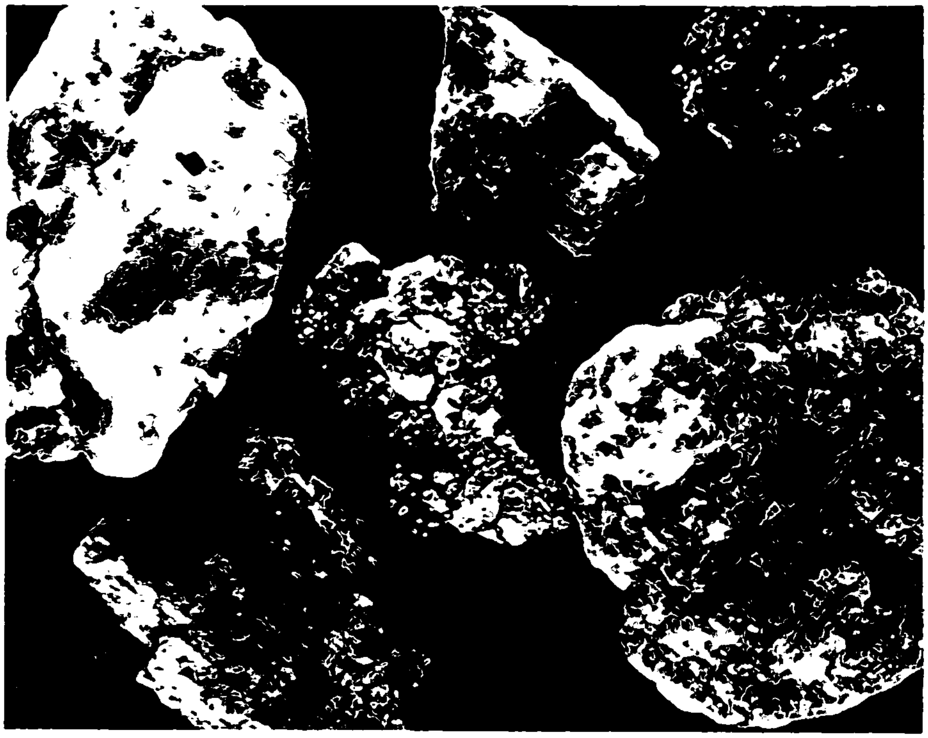


HEAD ORE

Photomicrograph showing aggregate of euhedral pyrite crystals (creme colored) intergrown with siliceous gangue (greenish grey).

SCALE = 100 microns *200x*

FIGURE 4

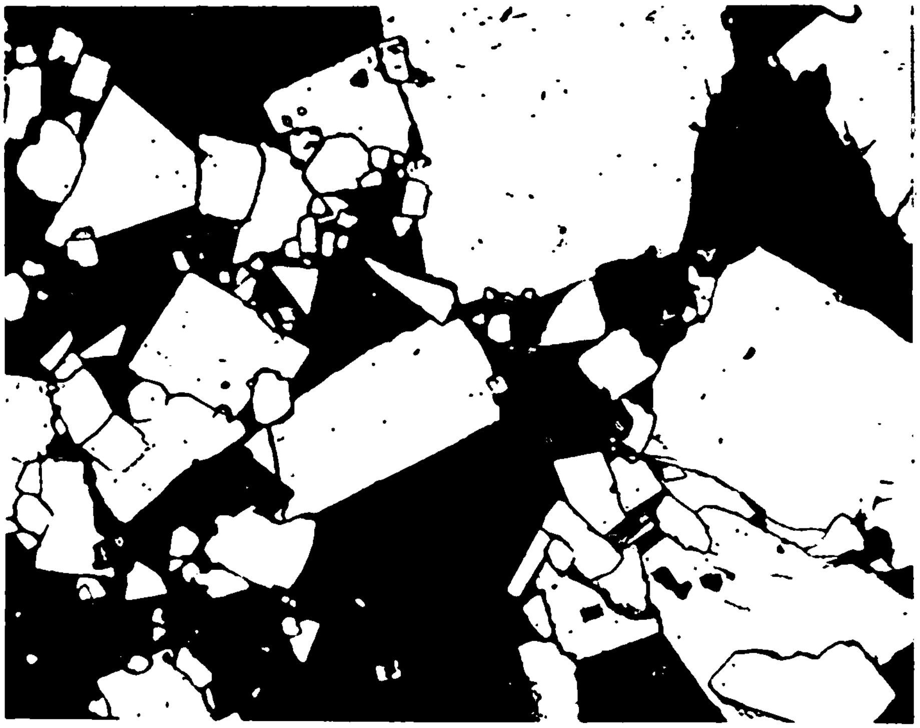


LEACH RESIDUE

Photomicrograph of selected particles illustrating square solution cavities derived from leaching of euhedral pyrite crystals and residual liberated coarse pyrite showing corrosion effects.

SCALE = 3 microns *200x*

FIGURE 5

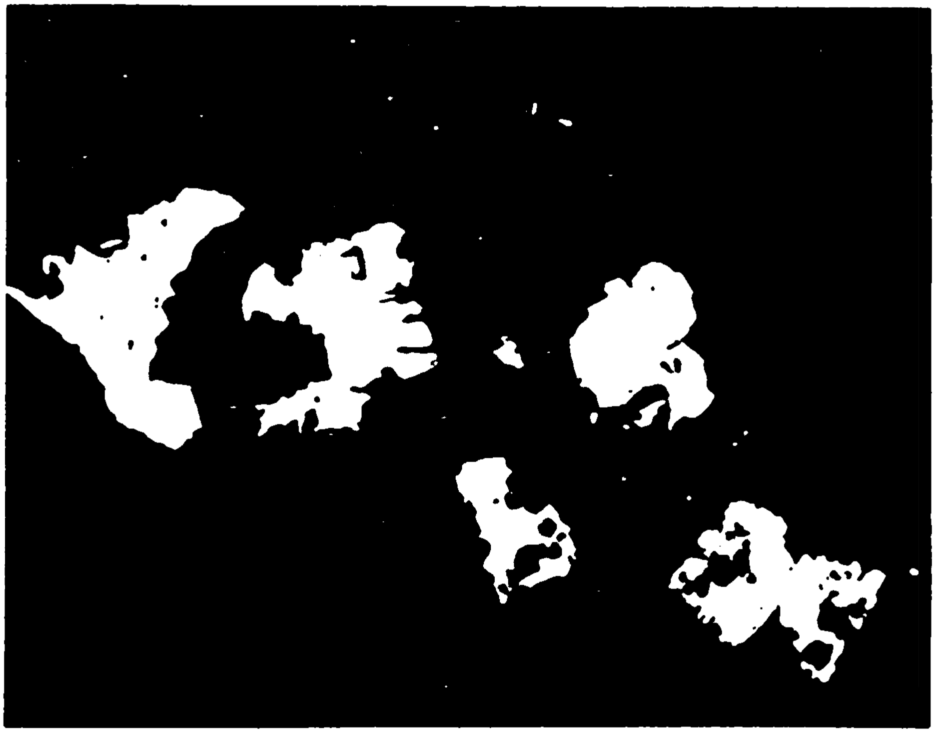


LEACH RESIDUE

Polished section showing example of encapsulated pyrite crystal aggregate totally unaffected by the acid leaching.

SCALE = 100microns *200x*

FIGURE 6



LEACH RESIDUE

Photomicrograph illustrating both partially leached pyrite crystals and complete pyrite dissolution (square and oblong outlines marking cavities formerly occupied by euhedral pyrite).

SCALE = 100 microns *200x*

FIGURE 7

LEACH RESIDUE

Example of unleached pyrite in impervious gangue and solution cavity (rhomb shaped outline) of leached out crystal located at a fracture.

SCALE = 100 microns *200x*

FIGURE 8

CONCLUSIONS AND RECOMMENDATIONS

In respect of the principal objective of this project of determining the minimum degree of oxidation which results in economically important gold recovery increases, the test results suggest that a linear and equal relationship exists between oxidation and gold solubiltiy in cyanide. This suggestion is based on the gold recoveries of approximately 77.5 to 81.4% (depending on calculated head) and the corresponding approximately 80.2% sulfide sulfur conversion. The result is supported by the mineralogy results which indicated clearly that higher acid addition likely would yield more complete oxidation and, hence, possibly higher gold recovery.

Having now established that the 3/8-inch crushed Gilt Edge ore is amenable to the nitric acid oxidation, it is recommended that additional testing would be advisable to define the oxidation/dissolution relationship more conclusively. The amount of sulfides that are oxidized translates directly to the quantity of nitric acid required to result in a satisfactory gold dissolution. The nitric acid quantity is vital factor since, commercially, it is the cost for regeneration which will determine the economic viability of this oxidation method. Previous commercial evaluations showed that the largest capital and operating cost factors are associated with nitric acid regeneration. However, several approaches have now been identified to minimize the relative costs for regeneration.

Previous experience has also showed that the rates of oxidation can be increased substantially using higher nitric acid additions to the initial ore contact, and by using concentrated nitric acid rather than diluted forms to the extent that oxidation is accomplished in minutes, rather than many hours or days. Since no moisture (water) is added, the utilization of acid is very high to the extent that as much as 99% of the HNO_3 added is converted (from the chemical equation) almost immediately to NO_x which is regenerated readily by water absorption to HNO_3 which is recycled back to the ore reaction. The Gilt Edge ore appears to be suitable for such high rate reactivity based on the physical measurement data and mineralogy which shows the material to be relatively porous. Good porosity is a key element of successful oxidation of crushed ore. Therefore, the oxidation reaction is rapid enough to permit the use of sealed reactor equipment, such as a rotary kiln, which lends itself well to efficient off-gas collection. Such a system has been piloted successfully on other refractory gold ores.

Follow up laboratory test work, therefore, should be performed on the Gilt Edge crushed ore to evaluate high rate oxidation methods, with the goals of establishing the maximum oxidation rate in relation the nitric acid quantity. It would also be advisable to bracket coarser and finer ore crushing sizes so that the minimum crushing requirement can be determined. Such test work can be carried out readily using a bench scale reactor which simulates reliably pilot and commercial-sized rotary equipment.

Future work should also evaluate the important washing behavior of the oxidized ore. Experience shows that effective washing of soluble components and residual acid can be accomplished readily using a belt extractor (filter). The filtrate or acid effluent is neutralized with stoichiometric quantities of alkali, such as lime, to produce a stabilized sludge for disposal. This effluent neutralization step is common to most acidic oxidation methods. After being washed, the oxidized ore is further neutralized with lime and placed on conventional permanent, stacked, pads for cyanide heap leaching for gold and silver recovery. Since the oxidation and washing steps are performed using equipment which provide short retention times, there is no need to move the ore from an oxidation/washing pad to a permanent cyanide leach pad, and this is an important merit of high rate oxidation methods. The heap leaching of the nitric acid oxidized ore is viewed as being essentially the same as heap leaching of geologically oxidized materials. Previous column test work showed that gold dissolutions were levelled off typically after two to three weeks, and optimized sodium cyanide consumptions were approximately 1 lb/ton of ore or less. Confirming column (simulated-heap) leaching tests, therefore, also should be conducted on the oxidized and washed Gilt Edge sample.

The above test work will serve as a sound basis for a preliminary feasibility campaign and selected pilot scale tests.

APPENDIX

For documentation of the information presented in this report, the following Appendix section contains copies of metallurgical balance and test operating reports as received from CMRI. Analytical reports are on permanent file at CMRI.

APPENDIX A

CMRI TEST REPORTS

COLORADO
MINERALS
RESEARCH
INSTITUTE

Sample Receiving Log Sheet

Date Received: July 11, 1994

Received By: L M Matulovich

Project #: 943002

Project Metallurgist: T. Hertel

Check Against Delivery Manifest

Supplier (Client) Name:	Brohm Mining Corp.				
Manifest Weight:	250 pounds Est. U.P.S. no Manifest				
Sample Containers:	Type Plastic Pails	No.	8	Condition	very good
	Type	No.		Condition	
	Type	No.		Condition	
Hazardous:	X No ___ Yes	If yes: Assign sample to appropriate party for completion of HazMat Receiving Log.			
	Sample Assigned To:				

Sample Identification

Client No./Identification	Weight	CMRI Sample No.	Description (by Project Metallurgist)
JT5	12.480 Kg	943002-01	
JT 8	13.370 Kg	943002-02	
JT 4	12.959 Kg	943002-03	
JT 1	12.805 Kg	943002-04	
JT 2	13.076 Kg	943002-05	
JT 7	13.100 Kg	943002-06	
JT 3	12.857 Kg	943002-07	
JT 6	12.462 Kg	943002-08	
	103.12 Kg (227 lb)		

(continued on back)

PROCEDURE

Receive Samples →
- Check Against Manifest
- Sign Drivers Copy

Log-in Samples
→ Non-Hazardous →
- Get Project No.
- Weight
- Assign CMRI No.

→ Hazardous →
- Get Project No.
- Assign Appropriate Party

Project Metallurgist →
- Record Sample Description
- Original to Administration

Assignee →
- Complete HazMat Receiving Log
- Copy to Project File
- Original to Administration (HazMat File)

→ Administration
- Copy to Database
- Original to Project File

QUANTACHROME
FIRST IN POWDER TECHNOLOGY

1900 Corporate Drive
Boynton Beach, FL 33426
Tel (407) 731-4999
Fax: (407) 732-9888

FAX MESSAGE

TO: Colorado Minerals Research

ATTENTION: Terry M. Hertel

FAX NO: (303) 279 6061

FROM: Dan Grossmann

DATE: 14 November, 1994

SUBJECT: Recalculation of QC# 94-5180 results (faxed 8/19/94)

Dear Mr. Hertel:

As per request of Doug Shaw (Phone/Fax: (303) 670 0956), attached please find the 8/19/94 results (surface area, pore volume, and average pore size) calculated in the same format as the October 19, 1994 (QC # 94-5587) data. As you can see, the recalculations are the same as the initial calculations.

Sincerely,

Daniel W. Grossmann

Daniel W. Grossmann
Lab Supervisor

Date: 08/19/94

Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Micropore Version 2.44

Sample ID................	COLORADO MINERALS RESEARCH INSTITUTE					
Sample Description......	Ore					
Comments.................	CMRI, QC # 94-5180					
Gas Type.................	Nitrogen					
Cross-Sec Area.. 16.2	Å²	Corr Factor..	6.580E-05	Molec Wgt..	28.0134	
Sample Weight... 10.6620	g	P/Po Toler...	1	File Name..	A5481802.RAW	
Analysis Time... 177.0	min	Equil Time...	3	Operator...	BEM	
Outgas Time..... 8.0	hrs	Outgas Temp..	105 °C	Station #..	1	
End of Run...... Fri Aug	19 08:10:19					

MULTI-POINT BET

P/Po	Volume [cc/g] STP	1/(W((Po/P)-1))
5.0000e-02	0.3525	1.195E+02
1.0250e-01	0.3962	2.307E+02
1.5340e-01	0.4273	3.393E+02
2.0400e-01	0.4504	4.553E+02
2.5400e-01	0.4737	5.751E+02

Area = 1.560E+00 [m²/g]

Slope = 2.229E+03

Y - Intercept = 3.445E+00

Correlation Coefficient = 0.9996

C = 6.479E+02

Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Micropore Version 2.44

Sample ID...............	COLORADO MINERALS RESEARCH INSTITUTE					
Sample Description......	Ore					
Comments................	CMRI, QC # 94-5180					
Gas Type................	Nitrogen					
Cross-Sec Area.. 16.2	Å²	Corr Factor..	6.580E-05	Molec Wgt..	28.0134	
Sample Weight... 10.6620	g	P/Po Toler...	1	File Name..	A5481802.RAW	
Analysis Time... 177.0	min	Equil Time...	3	Operator...	BEM	
Outgas Time..... 8.0	hrs	Outgas Temp..	105 °C	Station #..	1	
End of Run...... Fri Aug	19 08:10:19					

TOTAL PORE VOLUME

Total pore volume = 1.443E-02 [cc/g] for

pores smaller than 1398.2 [Å] (Radius),

at P/Po = 0.99310

Date: 08/19/94

Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Micropore Version 2.44

Sample ID............... COLORADO MINERALS RESEARCH INSTITUTE
Sample Description...... Ore
Comments................ CMRI, QC # 94-5180
Gas Type................ Nitrogen

Cross-Sec Area..	16.2	Å²	Corr Factor..	6.580E-05		Molec Wgt..	28.0134
Sample Weight...	10.6620	g	P/Po Toler...	1		File Name..	A5481802.RA
Analysis Time...	177.0	min	Equil Time...	3		Operator...	BEM
Outgas Time.....	8.0	hrs	Outgas Temp..	105	°C	Station #..	1

End of Run...... Fri Aug 19 08:10:19

AVERAGE PORE SIZE

Average Pore Radius = 1.850E+02 [Å]

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1900 Corporate Drive
Boynton Beach, FL 33426, USA

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Fax: +1 407 732-9888

FAX MESSAGE

Date: 8/19/94 FAX #: (303) 279 6061 Page 1 of 4 Pages

To: Terry M. Hertel
Senior Metallurgist
Colorado Minerals Research Inst.

From: Beatriz Espindola M.

About: Analytical Report

Dear Mr. Hertel:

Attached please find the surface area (06000 -3N), pore volume and average pore size (06001 - P) reports.
If there are any questions please do not hesitate to contact us.

Sincerely

Beatriz Espindola M.

Date: 10/19/94

Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Micropore Version 2.44

Sample ID............... Colorado Minerals Research Institute
Sample Description......
Comments................ CMRI, QC # 94-5587
Gas Type................ Nitrogen

Cross-Sec Area..	16.2	Å²	Corr Factor..	6.580E-05		Molec Wgt..	28.0134
Sample Weight...	7.3263	g	P/Po Toler...	2		File Name..	AS4A1804.RAW
Analysis Time...	173.0	min	Equil Time...	3		Operator...	BEM
Outgas Time.....	36.0	hrs	Outgas Temp..	105	°C	Station #..	1

End of Run...... 10-19-94 19:42pm

MULTI-POINT BET

P/Po	Volume [cc/g] STP	1/(W((Po/P)-1))
1.0214e-01	1.7850	5.099E+01
1.4762e-01	1.9422	7.135E+01
2.0007e-01	2.1060	9.502E+01
2.4813e-01	2.2540	1.171E+02
2.9870e-01	2.4198	1.408E+02

Area = 7.557E+00 [m²/g]

Slope = 4.568E+02

Y - Intercept = 4.011E+00

Correlation Coefficient = 1.0000

C = 1.149E+02

Date: 10/19/94

Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Micropore Version 2.44

Sample ID............... Colorado Minerals Research Institute
Sample Description......
Comments................ CMRI, QC # 94-5587
Gas Type................ Nitrogen

Cross-Sec Area..	16.2	Å²	Corr Factor..	6.580E-05	Molec Wgt..	28.0134
Sample Weight...	7.3263	g	P/Po Toler...	2	File Name..	AS4A1804.RAW
Analysis Time...	173.0	min	Equil Time...	3	Operator...	BEM
Outgas Time.....	36.0	hrs	Outgas Temp..	105 °C	Station #..	1

End of Run...... 10-19-94 19:42pm

TOTAL PORE VOLUME

Total pore volume = 2.692E-02 [cc/g] for

pores smaller than 1337.0 [Å] (Radius),

at P/Po = 0.99278

Quantachrome Corporation
Quantachrome Autosorb Automated Gas Sorption System Report
Micropore Version 2.44

Sample ID............... Colorado Minerals Research Institute
Sample Description......
Comments................ CMRI, QC # 94-5587
Gas Type................ Nitrogen

Cross-Sec Area..	16.2	Å²	Corr Factor..	6.580E-05	Molec Wgt..	28.0134
Sample Weight...	7.3263	g	P/Po Toler...	2	File Name..	AS4A1804.RAW
Analysis Time...	173.0	min	Equil Time...	3	Operator...	BEM
Outgas Time.....	36.0	hrs	Outgas Temp..	105 °C	Station #..	1
End of Run......	10-19-94 19:42pm					

AVERAGE PORE SIZE

Average Pore Radius = 7.124E+01 [Å]

CMRI
Project # 943002

Test Type: Baseline Bottle Roll

Product Name/Type	Weight/Volume (grams/mls)	Assays (oz/T or mg/l) Au	Units (mg) Au	Distribution (%) Au	Assays (oz/T or mg/l) Ag	Units (mg) Ag	Distribution (%) Ag
Pregnant Liquor	1090.0	0.42	0.46	32.82	1.29	1.41	39.29
Wash Liquor	480.0	0.09	0.04	3.11	0.25	0.12	3.35
Residue	998.1	0.026	0.89	64.07	0.060	2.05	57.36
Totals:			1.39	100.00		3.58	100.00
If Preg + Wash:	1570.0	0.18	0.50	35.93	0.55	1.53	42.64
Calc'd Head:		0.041			0.105		
Assay Head:	998.3	0.044			0.210		
Accountability (%)		92.2			49.8		

Cyanide Consumption (lbs/T):

Lime Use (lbs/T):

Test Type: Baseline Bottle Roll "Duplicate"

Product Name/Type	Weight/Volume (grams/mls)	Assays (oz/T or mg/l) Au	Units (mg) Au	Distribution (%) Au	Assays (oz/T or mg/l) Ag	Units (mg) Ag	Distribution (%) Ag
Pregnant Liquor	1111.0	0.41	0.45	41.89	1.27	1.41	46.72
Wash Liquor	568.0	0.13	0.07	6.87	0.41	0.23	7.71
Residue	1003.4	0.016	0.55	51.24	0.040	1.38	45.56
Totals:			1.07	100.00		3.02	100.00
If Preg + Wash:	1679.0	0.19	0.52	48.76	0.60	1.64	54.44
Calc'd Head:		0.031			0.088		
Assay Head:	1000.1	0.044			0.210		
Accountability (%)		71.0			41.8		

Cyanide Consumption (lbs/T):

Lime Use (lbs/T):

CMRI
Project # 943002

Test Type: Bottle Roll on Test 3 Residue

Product Name/Type	Weight/Volume (grams/mls)	Assays (oz/T or mg/l) Au	Units (mg) Au	Distribution (%) Au	Assays (oz/T or mg/l) Ag	Units (mg) Ag	Distribution (%) Ag
Pregnant Liquor	1000.0	0.82	0.82	43.98	3.00	3.00	51.86
Wash Liquor	0.0	0.00	0.00	0.00	0.00	0.00	0.00
Residue	1015.4	0.030	1.04	56.02	0.080	2.78	48.14
Totals:			1.86	100.00		5.78	100.00
If Preg + Wash:	1000.0	0.30	0.82	43.98	1.09	3.00	51.86
Calc'd Head:		0.054			0.166		
Assay Head:	1000.0	0.044			0.210		
Accountability (%)		121.7			79.1		

Cyanide Consumption (lbs/T): 3.58

Lime Use (lbs/T): 39.80

CMRI
Project # 943002

Test Type: Bottle Roll on Test 4 Residue

Product Name/Type	Weight/Volume (grams/mls)	Assays (oz/T or mg/l) Au	Units (mg) Au	Distribution (%) Au	Assays (oz/T or mg/l) Ag	Units (mg) Ag	Distribution (%) Ag
Pregnant Liquor	1000.0	0.74	0.74	60.63	0.69	0.69	25.74
Wash Liquor	0.0	0.00	0.00	0.00	0.00	0.00	0.00
Residue	1001.1	0.014	0.48	39.37	0.058	1.99	74.26
Totals:			1.22	100.00		2.68	100.00
If Preg + Wash:	1000.0	0.27	0.74	60.63	0.25	0.69	25.74
Calc'd Head:		0.036			0.078		
Assay Head:	1000.0	0.044			0.210		
Accountability (%)		80.8			37.2		

Cyanide Consumption (lbs/T): 2.38

Lime Use (lbs/T): 18.64

CMRI
Project # 943002

Test Type: Bottle Roll on Test 5 Residue

Product Name/Type	Weight/Volume (grams/mls)	Assays (oz/T or mg/l) Au	Units (mg) Au	Distribution (%) Au	Assays (oz/T or mg/l) Ag	Units (mg) Ag	Distribution (%) Ag
Pregnant Liquor	1000.0	0.74	0.74	53.18	0.68	0.68	20.69
Wash Liquor	0.0	0.00	0.00	0.00	0.00	0.00	0.00
Residue	1000.4	0.019	0.65	46.82	0.076	2.61	79.31
Totals:			1.39	100.00		3.29	100.00
If Preg + Wash:	1000.0	0.27	0.74	53.18	0.25	0.68	20.69
Calc'd Head:		0.041			0.096		
Assay Head:	1000.0	0.044			0.210		
Accountability (%)		92.2			45.6		

Cyanide Consumption (lbs/T): 2.14

Lime Use (lbs/T): 19.18

CMRI
Project # 943002

Test Type: Bottle Roll on Nitric Acid Oxidation Residue

Product Name/Type	Weight/Volume (grams/mls)	Assays (oz/T or mg/l) Au	Units (mg) Au	Distribution (%) Au	Assays (oz/T or mg/l) Ag	Units (mg) Ag	Distribution (%) Ag
Pregnant Liquor	625.0	1.07	0.67	45.11	3.13	1.96	37.47
Wash Liquor	1560.0	0.28	0.44	29.46	0.88	1.38	26.41
Residue	1000.0	0.011	0.38	25.43	0.055	1.89	36.12
Totals:			1.48	100.00		5.22	100.00
If Preg + Wash:	2185.0	0.40	1.11	74.57	1.21	3.34	63.88
Calc'd Head:		0.043			0.152		
Assay Head:	1000.0	0.044			0.210		
Accountability (%)		98.3			72.5		

Cyanide Consumption (lbs/T): 3.68

Lime Use (lbs/T): 24.30

CMRI
Project # 943002

Test Type: Bottle Roll Releach of Nitric Acid Oxidation Residue

Product Name/Type	Weight/Volume (grams/mls)	Assays (oz/T or mg/l) Au	Units (mg) Au	Distribution (%) Au	Assays (oz/T or mg/l) Ag	Units (mg) Ag	Distribution (%) Ag
Pregnant Liquor	152.0	0.10	0.01	11.30	0.48	0.07	25.93
Wash Liquor	690.0	0.03	0.02	14.66	0.09	0.06	22.07
Residue	284.6	0.010	0.10	74.04	0.015	0.15	52.01
Totals:			0.13	100.00		0.28	100.00
If Preg + Wash:	842.0	0.01	0.03	25.96	0.05	0.14	47.99
Calc'd Head:		0.014			0.029		
Assay Head:	283.0	0.011			0.055		
Accountability (%)		122.8			52.4		

Cyanide Consumption (lbs/T): 0.98

Lime Use (lbs/T): 16.10

Leach Testing Report

Date: 8/8/94

Project #: 943002

Sample #: BR 01

Sample Description: Baseline Bottle Roll

Objective:

Test Conditions:

Wt Solids: 998.3 grams

Wt Soln: 998 mls

% Solids:

Grind:

% Passing Mesh

Bottle Tare ~~WEIGHT~~ 949.2 grams 1,947.5

Carbon Added: grams

Final Carbon Weight: grams

Total Wt w/ Lid: grams

After: grams

Target pH:

NaCN Conc: lb/T

NaCN Wt: grams

Test Record:

	~~Stage~~ Day	Time (hrs)	pH	Eh (mv)	grams NaCN Added	grams Lime Added	Soln Removed (mls)	Initial Volume	Final Volume	Free NaCN (grams/lbs/T)	~~Dissolved~~ O2 (ppm)	
7/8		3:00 0	2.6/11.6		0.49	4.52						
8/9	1	1:00 2	10.1/11.1		0.82	0.27	95.9	0.00	0.38	0.17	904.5	2950
8/10	2	2:00 4	9.9/11.4		0.42	1.00	87.1		1.26	0.57	905.4	2947
8/11	3	3:00 6	10.3/11.1		0.76	0.45	131.4		1.68	0.73	865.7	2940
8/12	4	2:30 8	10.5/11.2		~~0.[illegible]~~	0.34	100.8		1.84	0.84	916.0	2944
8/15	7	9:00 [illegible]	10.6/11.3		0.21	0.31	89.0		1.74	0.78	900.5	2964
8/19	11	11:00 [illegible]	9.7/11.2		0.50	0.36	100.3		1.12	0.49	879.6	2937
8/22	14	72	9.95									2927
												2941
						Σ 7.25						

2.71 (consumed)

5.42 lb/T

Preg Volume: 1,090 mls

Wash Volume: 480 mls

Dry Residue Weight: 998.1 g

14.5 lb/T

Leach Testing Report

Date: 8/8/94

Project #: 94308Z

Sample #: BR07

Sample Description: Baseline Bottle Roll

Objective:

Test Conditions:

Wt Solids: 1000.1 grams

Wt Soln: 1,000 mls

% Solids:

Grind:

% Passing Mesh

Bottle Tare ~~wt~~: 944.7 grams 1,944.3

Carbon Added: grams

Final Carbon Weight: grams

Total Wt w/ Lid: grams

After: grams

Target pH: NaCN Conc: lb/T NaCN Wt: grams

Test Record:

Target wt=2948.

	~~Stage~~ Day	Time (hrs)	pH	Eh (mv)	grams NaCN Added	grams Lime Added	Soln Removed (mls)	Initial Volume	Final Volume	Free NaCN (grams/lbs/T)	~~Dissolved~~ O2 (ppm)	
8/8		3:00	2.6/11.6		1.00	4.39						2950. / ~~2948.3~~
8/9	1	1:00	10.1/11.1		0.84	0.22	72.9	0.00	0.34	0.16	930.5	2947.
8/10	2	7:00	9.9/11.4		0.39	1.70	83.9	0.00	1.32	0.61	917.2	2945.
8/11	3	3:00	10.6/11.1		0.21	0.29	109.1		1.78	0.79	892.7	2946.
8/12	4	2:30	10.7/11.2		~~0.07~~	0.37	85.3		2.02	0.93	918.4	2948
8/15	7	9:00	10.2/11.3		0.22	0.38	93.2		1.72	0.78	902.7	2940.
8/19		11:00	10.2/11.2		0.34	0.30	107.9		1.62	0.76	943.1	2995
8/22		72	10.2									2,947
						Σ: 7.15						

2.24 g consumed

4.48 lb/T

Preg Volume: 1,111 mls

Wash Volume: 568 mls.

Dry Residue Weight: 1003.9 g

14.3 lb/T

CMRI
Oxidation Testing Report

PROJECT #: 943002   8/15/94

SAMPLE #: RB 3

DESCRIPTION: Ferric Sulfate 36.75 g/l.

OBJECTIVE: pH ≅ 1.0

TEST CONDITIONS: 3,900.2

Wt Solids: 2,001.8 grams   Bottle Tare w/ Lid: 1,898.4 grams

Wt Soln: 1,976.8 ~~mls~~ g.   Total Wt w/ Lid: ________ grams

% Solids: ________   After: ________ grams

GRIND:

________ % Passing ________ Mesh

TEST RECORD:

Date	Day	pH	Eh (mv)	Post-Filter (grams)	Pre-Filter (grams)	Soln Removed (mls)	H2O Added (mls)	H_2SO_4 Reagent Added (grams)	Ferric Sulfate ~~Dissolved O2 (ppm)~~	Solution Weight (g)
8/16	0	1.57/0.8	520	5,793	5,877	81	81	61	9	
17	1	1.1/0.7	458	5,834	5,933	88	12	69.9	72.65	
18	2	1.83/0.75	431	5,800	5,902	102 ~~97~~	4	79.2		
19	3	1.13/0.80	425	5,770	5,883	113	77	97.1		
20	4				~~5873~~					
21	5									
22	6	0.77	427	5,762	5873	111.0	115	~~0~~		
23	7	0.77	434	5,765	5865	100	112	~~0~~		
24	8	1.00/0.8	419	5,766	5869	103	81	30		
25	9	0.81	427	5,768	5869	101	109	~~0~~		
26	10	1.18/0.83	421	5,777	5869	97	87	23		
	11									
	12									
29	13	0.98	414	5,754	5851	97	97	26		
30	14	0.85	404	5,764	5868	104	40		72.65	
31	15	1.20	426	5,777	5872	95	58	64		
9/1	16	0.94	471	5,796	5893	98	95			
9/2	17	0.87	430	5,799	5885	86	88			
3	18				~~5888~~					
	19									
	20									
6	21	0.91	421		~~5888~~	1980				
	22									
	23									
	24									
	25									

CMRI
Oxidation Testing Report

PROJECT #: 943002   8/15/94

SAMPLE #: BR 4

DESCRIPTION: Sodium Chlorate 20 g/l.

OBJECTIVE: pH <1.0

TEST CONDITIONS:

Wt Solids: 2001.7 grams

Wt Soln: 1,959.7 ~~mls~~ g

% Solids: ______

Bottle Tare w/ Lid: 1,874.6 grams

3,876.3

Total Wt w/ Lid: ______ grams

After: ______ grams

GRIND:

______ % Passing ______ Mesh

TEST RECORD:

HCL $NaClO_3$ (s)

Date	Day	pH	Eh (mv)	Post-Filter (grams)	Pre-Filter (grams)	Soln Removed (mls)	H2O Added (mls)	Reagent Added (grams)	~~Dissolved O2~~ (ppm)	Solution Weight (g)
8/16	0	1.78	604	5,747	5836	94	94		39.20	
17	1	1.76	578	5,777	5878	101	109			
18	2	1.47	546	5,776	5,876	100	110			
19	3	1.47	560	5,739	5,844	105	123			
	4				5,843					
	5									
22	6	1.57	537	5,740	5,843	103	96			
23	7	1.40 0.85	578	5,742	5878	86	94	60		
24	8	0.80	522	5,737	5832	100	104			
25	9	0.74	490	5,737	5829	92	99			
26	10	0.84	479	5,730	5878	98	106			
	11									
	12									
29	13	0.90	448	5,727	5826	99	109			
30	14	0.90	457	5728	5829	101	86	22		
31	15	1.20	439	5,722	5830	108		40		
9/1/94	16	0.92	456	5,717	5830	113	119			
2	17	1.10	460	5,739	5853	94		36		
	18									
	19									
	20	1.08								
6	21	~~1.26~~	451		5823	2130				
	22									
	23									
	24									
	25									

CMRI
Oxidation Testing Report

PROJECT #: 94300Z 8/15/94

SAMPLE #: RR 5

DESCRIPTION: Ferric Chloride (20g/l)

OBJECTIVE:

TEST CONDITIONS:

Wt Solids: 2,001.3 grams

Wt Soln: 1,980.2 ~~mls~~ g

% Solids:

Bottle Tare w/ Lid: 1,902.5 grams 3,903.8

Total Wt w/ Lid: grams

After: grams

GRIND:

% Passing Mesh

TEST RECORD:

HCL Ferric Chloride

Date	Day	pH	Eh (mv)	Post-Filter (grams)	Pre-Filter (grams)	Soln Removed (mls)	H2O Added (mls)	Reagent Added (grams)	~~Dissolved O2 (ppm)~~	Solution Weight (g)
8/16	0	1.25	578	5,784	5,884	100	100		(9)	
17	1	0.89	530	5,775	5,877	102	~~117~~ 109		39.6	
18	2	1.07	498	5,781	5,874	93	103			
19	3	1.18	487	5,759	5,875	116	125			
	4				~~5,856~~					
	5									
22	6	1.24	464	5763	5856	93	121			
23	7	1.85	458	5,754	5874	117	130	36		
24	8	0.75	447	5,776	5876	100	108	8		
25	9	0.91	454	5776	5874	98	108			
26	10	0.80	447	5,777	5874	97	107			
	11									
	12									
29	13	0.87	431	5,757	5855	98			39.8 g	
30	14	1.00	420	5775	5877	~~9~~ 102	49	21.0	~~40.0 g~~	
31	15	1.15	463	5782	5878	96		25.0		
9/1/94	16	.87	464	5,773	5878	105	111			
2	17	0.89	466	5,783	5879	96				
	18									
	19									
	20									
6	21	1.03	457		5865	2205				
	22									
	23									
	24									
	25									

CMRI
Oxidation Testing Report

PROJECT #: 943002

SAMPLE #: R.B. Co

DESCRIPTION: HNO_3

OBJECTIVE:

TEST CONDITIONS:

Wt Solids: 2,001.7 grams

Wt Soln: 2,006. ~~mls~~ g

% Solids: ____

Bottle Tare w/ Lid: 1905.3 grams 3,907.0

Total Wt w/ Lid: ____ grams

After: ____ grams

GRIND:

____ % Passing ____ Mesh

TEST RECORD:

Date	Day	pH	Eh (mv)	Post-Filter (grams)	Pre-Filter (grams)	Soln Removed (~~mls~~ g)	H2O Added (mls)	Reagent Added (grams)	Dissolved O2 (ppm)	Solution Weight (g)
8/16	0	0.54	797	5,806	5913	107	~~107~~ 131			
8/17	1	0.45	720	5823	5,937	114	101			
18	2	0.67	700	5,812	5924	112	112			
19	3	0.37	703	5,821	5918	97	92			
20	4				~~5,913~~					
21	5									
22	6	0.76	715	5807	5,913	111	111	865 mls		75.7 g ? ~~[illegible]~~
23	7	0.61	720	5,669	5,774	102	~~[illegible]~~			
24	8	0.60	714	5803	5,911	108	110			
25	9	0.65	715	5805	5,908	103	108			
26	10	0.60	711	5816	5909	93	97			
	11									
	12									
29	13	0.77	681	~~[illegible]~~	5907	~~[illegible]~~				
	14					2735				
	15									
	16									
	17									
	18									
	19									
	20									
	21									
	22									
	23									
	24									
	25									

Leach Testing Report

Date: 9/13/94

Project #: 943002

Sample #: Test 8

Sample Description: Leach Residue from Test 3

Objective:

Test Conditions:

Wt Solids: 1,000. grams

Wt Soln: 1,000 mls

% Solids:

Grind:

% Passing ______ Mesh

Bottle Tare w/ Lid: 1803 grams

Carbon Added: ______ grams

Final Carbon Weight: ______ grams

Total Wt w/ Lid: ______ grams

After: ______ grams

Target pH: ______

NaCN Conc: ______ lb/T

NaCN Wt: ______ grams

Test Record:

Stage	Time (hrs)	pH	Eh (mv)	grams NaCN Added	grams Lime Added	Soln Removed (mls)	Initial Volume	Final Volume	Free NaCN (grams/liter)	Dissolved O2 (ppm)	
9/13	10:45	1.90									
	2	11.00		1.0	13.04		..		1.0		3,803
	4	~~9.3~~ 11.8		0.93	3.10		0.14		0.07		3,805
9/13	6:00 6	10.0/11.7				80					
9/14	1:30 8	9.8/11.2		0.40	2.84	~~78~~	0.	0.28	0.60		3,810
9/15	11:00 24	10.0/11.0		0.73	0.91	5 mls		1.44	0.77		3,888
	2:00 48	10.7									3914
	72										
					Σ: 19.89						

0.79 consumed

Preg Volume:

Wash Volume:

Dry Residue Weight: 1,015.4

L/T

Leach Testing Report

Date: 9/13/94

Project #: 943007

Sample #: Test 9

Sample Description: Leach residue from test 4

Objective:

Test Conditions:

Wt Solids: 1,000 grams

Wt Soln: 1,000 mls

% Solids:

Grind:

% Passing Mesh

Bottle Tare w/ Lid: 1,787 grams

Carbon Added: grams

Final Carbon Weight: grams

Total Wt w/ Lid: grams

After: grams

Target pH:

NaCN Conc. lb/T

NaCN Wt: grams

Test Record:

Stage	Time (hrs)	pH	Eh (mv)	grams NaCN Added	grams Lime Added	Soln Removed (mls)	Initial Volume	Final Volume	Free NaCN (grams/l)	Dissolved O2 (ppm)	
9/13	10:45	7.21									
	2	11.3		1.0	4.48				1.0		3787
9/13	6:00	9.6/11.1		0.58	1.69	80.6g		0.84	0.42		3,782
9/14	1:30	10.0/11.2		0.39	1.55	75.6g		1.30	0.61		3794
9/15	8	10.6/11.2		0.11	1.60	5 mls		1.77	0.89		3797
	7:03	11.6									3,815
	48										
	72										
					2.9.32						

0.19g consumed

2.38

Preg Volume:

Wash Volume:

Dry Residue Weight: 1,001.1g

Leach Testing Report

Date: 9/6/94

Project #: 943002

Sample #: BR 7

Sample Description: Leach residue from test 6

Objective:

Test Conditions:

Wt Solids: 1,000 grams

Wt Soln: 1,000 mls

% Solids: 50

Grind:

_____ % Passing _____ Mesh

Bottle Tare w/ Lid: 1,790.7 grams 2,790.2gr

Carbon Added: _____ grams

Final Carbon Weight: _____ grams

Total Wt w/ Lid: _____ grams

After: _____ grams

Target pH: 11.5

NaCN Conc: 0.5 ~~lb/T~~ g/kg

NaCN Wt: 1.0 grams

Test Record:

Stage	Time (hrs)	pH	Eh (mV)	grams NaCN Added	grams Lime Added	Soln Removed (mls)	Initial Volume	Final Volume	Free NaCN (grams/lbs/T)	Dissolved O2 (ppm)	
9/6	10:45	1.66									
	10:30 3	11.61		1.0	9.4		..				3,831
9/7	9:30 24	9.6/11.2		0.91	1.23	82	000	0.18	0.09	7.1	3,826
	3:30 6	10.3/11.1		0.33	0.79			1.30	0.67		3826
9/8	7:30 8	10.3/11.1		0.52	0.73			0.92	0.48		3829
	11:20 24	10.8						1.58	0.92		3959
	48										
	72										
					Σ: 12.15g						

1.44g consumed

3.6 lb/T

Preg Volume: 625

Wash Volume: 1,560.

Dry Residue Weight: 997.6gr

Leach Testing Report

Date: 9/13/94

Project #: 943002

Sample #: Test 8

Sample Description: Leach Residue from Test 3

Objective:

Test Conditions:

Wt Solids: 1,000. grams

Bottle Tare w/ Lid: 1803 grams

Wt Soln: 1,000 mls

Carbon Added: ______ grams

Final Carbon Weight: ______ grams

% Solids: ______

Total Wt w/ Lid: ______ grams

After: ______ grams

Grind:

______ % Passing ______ Mesh

Target pH: ______ NaCN Conc: ______ lb/T NaCN Wt: ______ grams

Test Record:

Stage	Time (hrs)	pH	Eh (mv)	grams NaCN Added	grams Lime Added	Soln Removed (mls)	Initial Volume	Final Volume	Free NaCN (grams/liter)	Dissolved O2 (ppm)	
9/13	10:45	1.90									
	2 11:00	11.00		1.0	13.04		..		1.0		3,803
	4	~~9.7~~ 11.8		0.93	3.10		0.14		0.07		3,805
9/13	6:00 6	[illegible]/11.7				80					
9/14	1:30	9.8/11.2		0.40	2.84	~~78~~	0.	0.78	0.60		3,810
9/15	11:00 24	10.0/11.0		0.73	0.91	5 mls		1.44	0.77		3,884
	2:00 48	10.7									3,914
	72										
					Σ: 19.89						

0.79
consumed

Preg Volume: ______

Wash Volume: ______

Dry Residue Weight: 1,015.4

Leach Testing Report

Date: 9/13/94

Project #: 943027

Sample #: Test 10

Sample Description: Leach residue from test 5

Objective:

Test Conditions:

Wt Solids: 1,000 grams

Wt Soln: 1,000 mls

% Solids:

Grind:

% Passing Mesh

Bottle Tare w/ Lid: 1,800 grams

Carbon Added: grams

Final Carbon Weight: grams

Total Wt w/ Lid: grams

After: grams

Target pH:

NaCN Conc: lb/T

NaCN Wt: grams

Test Record:

Stage	Time (hrs)	pH	Eh (mv)	grams NaCN Added	grams Lime Added	Soln Removed (mls)	Initial Volume	Final Volume	Free NaCN (grams/~~[illegible]~~)	Dissolved O2 (ppm)	
9/13	10:45	1.95									
	2	11.00		1.0	5.46				1.0		3,800
~~9/13~~	6:00 4	6:08	9.5/11.7	~~0.38~~	7.65			0.64	~~0.64~~	0.37	3,798
9/14	1:30 6	10.3/11.3		0.24	1.48	75.2		1.64	0.76		3,800
9/15	8	11.0		0.05	—	5 mls		1.92	0.95		3,792
	24	11.0									3,821
	48										
	72										
					Σ: 9.59 g						

1.07 g consumed

Preg Volume:

Wash Volume:

Dry Residue Weight: 1,000.4

2.14 lbs/T

Date: 9/26/94

Project #: 943002

Sample #: BR 11

Sample Description: Residue from Leach Test #7 (HNO3 Oxidation/CN⁻ Leach)

Objective:

Test Conditions:

Wt Solids: 283 grams

Wt Soln: 283 mls

% Solids: 50

Grind:

% Passing, Mesh

Bottle Tare 769 grams 552.

Carbon Added: grams

Final Carbon Weight: grams

Total Wt w/ Lid: grams

After: grams

Target pH: 11.25

NaCN Conc: 0.5 lb/T

NaCN Wt: 0.71 grams

Test Record:

Stage	Time (hrs)	pH	Eh (mV)	grams NaCN Added	grams Lime Added	Soln Removed (mls)	Initial Volume	Final Volume	Free NaCN (grams/lbs/T)	Dissolved O2 (ppm)	
9/26	1	8.6									835
	2	11.6			0.24						
	10:40 3	10.4		0.71							
	12:40 6	11.5		0.11	0.53		0.00	4.24	0.60		834
	2:40 8	10.9/11.5		0.07	0.27		0.00	4.54	0.64		834
Sample 24 hr	10:30 24	10.4/11.5		0.07	0.66		0.00	4.54	0.64		830
	8:00 48	10.6/11.5		0.12	0.58		0.00	4.08	0.59		842
	72										858
					Σ: 2.28						

0.49g consumed

0.98

Preg Volume: 152

Wash Volume: 690

Dry Residue Weight: 284.6